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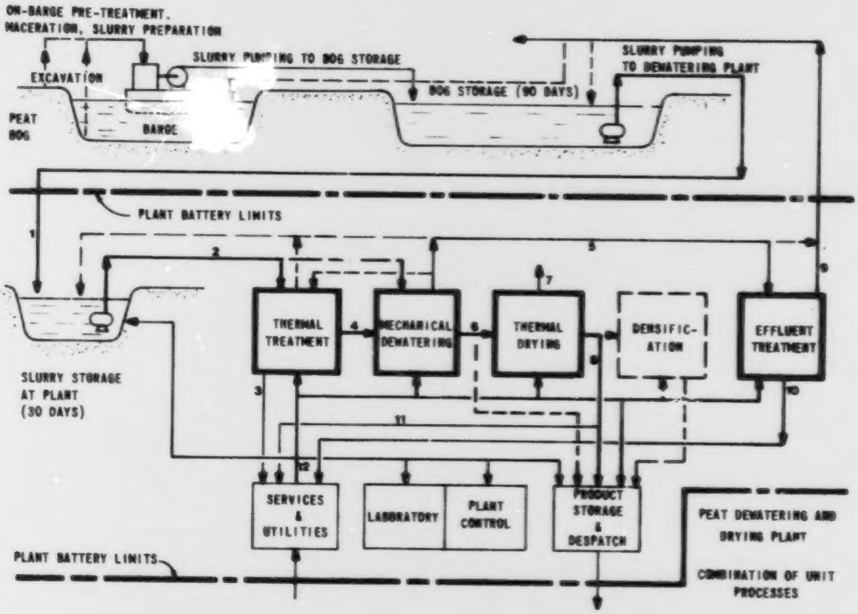
EVALUATION OF PEAT DEWATERING AND PEAT FUEL PROCESSES


ON-BARGE PRE-TREATMENT, MACERATION, SLURRY PREPARATION
EXCAVATION
PEAT BOG
BARGE
SLURRY PUMPING TO BOG STORAGE
BOG STORAGE (90 DAYS)
SLURRY PUMPING TO DEWATERING PLANT
PLANT BATTERY LIMITS
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SLURRY STORAGE AT PLANT (30 DAYS)
THERMAL TREATMENT
MECHANICAL DEWATERING
THERMAL DRYING
DENSIFIC-ATION
EFFLUENT TREATMENT
SERVICES & UTILITIES
LABORATORY
PLANT CONTROL
PRODUCT STORAGE & DESPATCH
PEAT DEWATERING AND DRYING PLANT
COMBINATION OF UNIT PROCESSES
PLANT BATTERY LIMITS

November 1983

MONTREAL ENGINEERING COMPANY, LIMITED

A MONENCO COMPANY

NATIONAL RESEARCH COUNCIL OF CANADA

PROCESS EVALUATION AND CONCEPTUAL DESIGN OF PLANT BASED ON A TECHNICAL AND ECONOMIC ASSESSMENT OF PEAT DEWATERING AND PEAT FUEL PROCESSES - PHASE I (UP-M-319-I)

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PART 1

INTRODUCTION, EXECUTIVE SUMMARY AND RECOMMENDATIONS

1.1 INTRODUCTION

The work of this study is divided into two phases. The scope of Phase I is evaluation of processes, while Phase II covers conceptual plant design based on one or more selected processes. Both phases include economic analysis.

This Phase I report is an evaluation of technologies and equipment for peat dewatering and fuel preparation. Based on the recommendations of Phase I, it is hoped that a conceptual plant design will be prepared in Phase II. If possible, the conceptual design will be resource specific so that, should the design indicate an adequate level of feasibility, the concept may be further developed at the same location.

A number of studies have been conducted during the seventies investigating the application of conventional dry mining technology, as extensively practiced in Europe, to the winning of Canadian fuel peat. Dry mining is dependent upon seasonal solar insolation and, consequently, upon the seasonal availability of operating and maintenance staff. A full year's supply of fuel has to be won in the summer months, stockpiled at the bog, and transported to the user plant all year. On account of fire hazard in the stockpile, peat can only be stored at the plant in small quantities for emergency use, and such storage normally constitutes about 7 stream days of plant consumption. In years when solar insolation has been below normal, peat production has been known to fall. For instance, in two of the last five years, peat production in Finland is reported to have been about 50% of the targetted quantity. This has resulted in idle plant capacity and greater consumption of fuel oil to balance the fuel peat deficit.

Ireland and Finland, two major peat users in Europe, obtain seasonal labour from agricultural communities around their peatlands for the summer harvesting of peat. The population densities in these areas have proved adequate for the purpose, and incentive is provided by the Government through various systems of subsidy. The use of an indigenous fuel resource replaces oil, which would otherwise have to be imported. The somewhat higher cost of the resulting energy (until the dramatic rise of oil prices in the last decade) is justified by a healthier balance of payments ledger for the country. Canadian peatlands are seldom surrounded by pools of potential labour seasonally occupied in agriculture. Many of the major bogs are located remotely enough to discourage temporary labour. The Canadian scenario is not, however, unique in these respects, as similar situations prevail in the northern areas of Finland and Sweden. The logistical problem may be one of the reasons why fuel peat and peat energy projects based on dry mining technology have not moved to project, or even demonstration, stages in Canada.

Currently, Finland and Sweden are investigating the application of wet mining technology in their more remote, northern peatlands, where dry mining would not be practicable. In this process, peat slurries are supplied to dewatering plants for the production of fuel peat. Peat dewatering technology based on wet mined peat is also under investigation in the northern United States. It is believed that application of these technologies to Canadian conditions may prove viable and deserves investigation. This assessment constitutes a step in that direction.

111 APPROACH

The study team worked towards achieving the Phase I objective in the following manner:

- A literature review was conducted of in-house and externally available material.

- Process developers and equipment manufacturers were approached for updated information on their technologies and equipment.

- Selected process developers and institutions conducting research in this field in Canada, U.S.A., and Europe were visited for first-hand information about their work and results.

- The information thus collected about each technology was then studied with two purposes in view:

  - o To determine the salient technical and economic features of each technology.

  - o To set down the information about each technology in a form which would most readily provide input to technical and economic evaluations.

- An analysis of evaluations is presented in Part 2 of this report. It takes data from the process evaluations carried out in Part 3, and provides the basis for the executive summary and recommendations of this report.

112 TECHNICAL OPTIONS

Figure 1-1 illustrates the prospective technical options for peat fuel production which have been evaluated by this study.

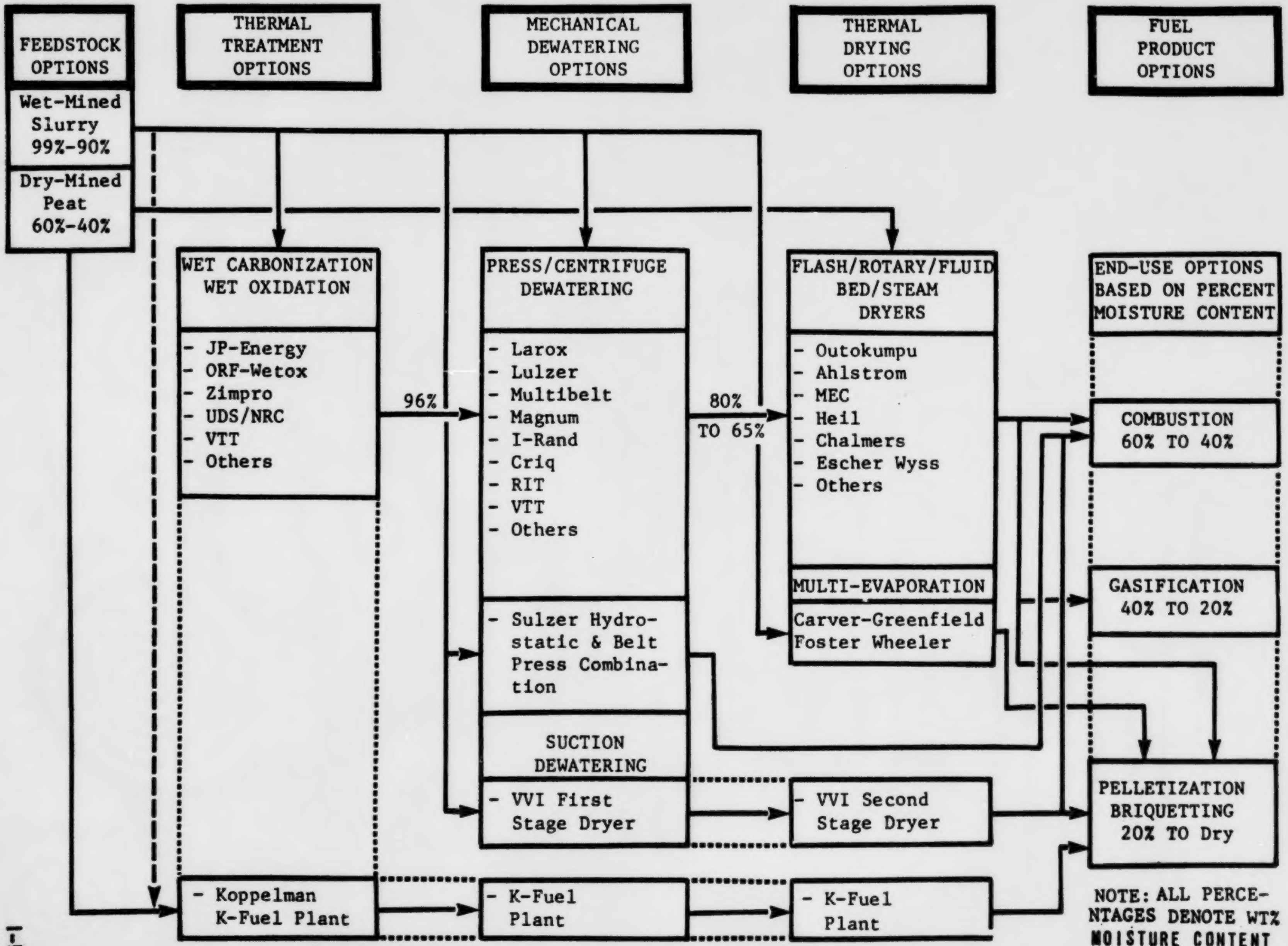
113 CRITERIA FOR TECHNICAL EVALUATION

The study commenced with establishment of standard criteria for technical evaluation of those technologies which were in the more advanced stages of development, so that information was sought uniformly under the following heads:

- Process History/Ratings of Laboratory, Pilot, Demonstration and Commercial Plants
- Feedstock Specifications/Storage
- Pre-Treatment of Feedstock
- Process Description, Flow Diagrams
- Design Considerations:
  - Major Equipment Specifications and Ratings
  - Auxiliary Equipment
  - Piping, Structures, Buildings, Roads and Foundations
  - Utilities and Off-Sites
  - Materials Selection
  - Instrumentation and Control
  - Reliability and Standby
  - Layout and Space Requirements
  - Maintenance and Replacement
  - Treatment/Disposal of Effluents and Plant Waste
  - Expected Plant Life
- Performance:
  - Materials and Energy Balance/Energy Recovery for Sale or Plant Use

FIGURE 1-1

PROSPECTIVE TECHNICAL OPTIONS FOR PEAT FUEL PRODUCTION AND USE


FEEDSTOCK OPTIONS
THERMAL TREATMENT OPTIONS
MECHANICAL DEWATERING OPTIONS
THERMAL DRYING OPTIONS
FUEL PRODUCT OPTIONS
Wet-Mined Slurry 99%-90%
Dry-Mined Peat 60%-40%
WET CARBONIZATION WET OXIDATION
- JP-Energy
- ORF-Wetox
- Zimpro
- UDS/NRC
- VTT
- Others
96%
PRESS/CENTRIFUGE DEWATERING
- Larox
- Lulzer
- Multibelt
- Magnum
- I-Rand
- Criq
- RIT
- VTT
- Others
- Sulzer Hydrostatic & Belt Press Combination
SUCTION DEWATERING
- VVI First Stage Dryer
80% TO 65%
FLASH/ROTARY/FLUID BED/STEAM DRYERS
- Outokumpu
- Ahlstrom
- MEC
- Heil
- Chalmers
- Escher Wyss
- Others
MULTI-EVAPORATION
Carver-Greenfield Foster Wheeler
- VVI Second Stage Dryer
END-USE OPTIONS BASED ON PERCENT MOISTURE CONTENT
COMBUSTION 60% TO 40%
GASIFICATION 40% TO 20%
PELLETIZATION BRIQUETTING 20% TO Dry
- Koppelman K-Fuel Plant
- K-Fuel Plant
- K-Fuel Plant

NOTE: ALL PERCENTAGES DENOTE WT% MOISTURE CONTENT

Sensitivity to Changes in Major Variables

Product Specifications

Optimum and Modular Plant Ratings

Environmental Review

Capital, Operating and Maintenance Costs

Economic Analysis

Current Status and Future Development Programs

Technologies in preliminary stages of development could not provide information under all headings.

114 CRITERIA FOR ECONOMIC EVALUATION

Criteria were established at the outset for conducting economic analyses on a standard format. It was a priority of the study to ensure that, in each evaluation, provision be made for all essential elements of project Capital Investment and Annual Cost on a standardized basis. Elements of cost have, therefore, been standardized for all economic analyses as follows:

- Capital Charges - On a sinking fund basis, a capital recovery factor for 20 years at 15% interest (0.159761) has been used in all evaluations.

- Capital Investment - Includes the following elements:

  . installed cost of equipment with contingency (*).

- construction, engineering, testing and commissioning, construction management.
- owner's costs include: taxes and insurance, administration, training, spare parts, environmental studies and licencing, working capital.
- escalation and IDC.

- Annual O&M Costs	- All elements are included.
- Annual Variable Costs	- All elements of variables and consumables costs (*) are included. (Note: for equality of processing cost comparison, feedstock costs and costs of effluent return to bog are uniformly excluded in the economic evaluation of comparable processes).

(*) Installed costs of major and auxiliary equipment and their requirements of utilities, services and consumables were, in all cases, provided by suppliers of equipment and by developers of process and technology. These elements were entered into the standard format and other elements of cost were factored from them. Using this prepared data specific costs of product and process were developed.

Where a plant comprises a number of process units, data has been obtained from process licencors to enable Monenco to break down plant costs for apportionment to individual unit processes. For example, where process plants consist of one or more of the following unit processes:

- slurry storage at plant
- thermal treatment of raw slurry
- mechanical dewatering
- thermal drying
- effluent treatment

the total plant Capital Investment and the total plant Annual Costs have, in each case, been broken down and apportioned to unit processes. Specific costs per unit process have thus been derived for a variety of technologies on a near comparable basis.

The costs developed by this study must be considered as being pre-feasibility level estimates which generally range (+)30%:(-)25%. It was outside the scope of this study to check the cost estimates provided by suppliers and process developers with regard to the installed costs of their plant equipment and auxiliaries. However, the costs were reviewed with them to check that all elements of plant, auxiliaries, services and off-sites were included in their estimates. The economic analysis prepared by Monenco for each major process was then provided to the supplier for review and approval. Where breakdowns were prepared by Monenco and costs apportioned to unit processes, these breakdowns were also sent to the process developers for review and comment. Adequate precautions have thus been taken to arrive at cost estimates, and analyses of specific costs of unit processes, which are as accurate as can be expected at this level of study.

In some cases where the specific costs, arising from the standardized economic analysis, did not cross-check credibly against comparable figures, Part 2.7 of the report comments upon the case and on the apparent causes of the discrepancy.

115 SPECIAL CONSIDERATIONS

The following aspects of plant and technology have received special consideration:

.1 Feedstock

The technology and economics of wet mining are beyond the scope of this study. Nevertheless, existing information on the subject is briefly reviewed, mainly because the characteristics of the feedstock have a major impact on dewatering process design and economics. The review finds that:

- Thermal treatment processes prefer to receive wet-mined peat in the form of a pumpable peat slurry, as distinct from peat excavated from the bog and conveyed by truck or conveyer to the plant. In order to achieve adequate pumpability a peat slurry would probably have to be macerated at the bog for pipelining to the plant.

- Mechanical dewatering processes prefer to receive peat which has been mechanically excavated and transported to the dewatering plant. However, it may be more difficult to clean the peat in this form, effectively removing stumps, roots, lumps, stones and other tramp material. Further, winter operations may pose greater problems to excavated than to slurried peat systems.

- Not enough is known about fuel peat wet-mining technology, maceration, slurry concentrations, pumping and piping, to enable firm determinations with regard to peat dewatering plant process design. Most thermal treatment processes have been designed on the basis of slurried peat feedstock, with concentrations ranging from 7% to 10% solids. As long as pumpability is assured, most process designs can be modified to accommodate a range of solids concentration in the slurry, and generally prefer a higher rather than a lower percentage of solids.

.2 Storage of Peat Slurry

It has to be considered that operation of wet mining systems may not be possible for more than 8 to 9 months of the year in Canada. For this reason storage of raw peat slurries assumes a special importance.

No data, based on experience, is currently available on this subject. For the purposes of this study it has been assumed that macerated raw peat slurry can be stored at the bog for 90 stream days of plant operation, and at the plant for 30 stream days of operation. It has also been assumed that slurry can be retrieved from storage for plant use during the winter.

This study has assumed that macerated peat slurry storage at the bog will constitute part of the peat mining and delivery system, costs for which are being developed by Monenco's peat resource and mining group. This thinking parallels the existing custom in dry mining practice where the bulk storage of milled or sod peat, and the delivery system to the user plant, are generally considered to lie within the scope of the mining and delivery systems.

Costs of peat slurry storage at dewatering plants have been developed and are presented in Part 2.2. Such storage is treated as a process unit of the dewatering plant (See Figure 2-1).

.3 Thermal Treatment and Heat Exchanger Performance

It is generally accepted that thermal treatment of peat slurry has the following advantages:

- it enhances the mechanical filterability of peat slurries;
- it enhances the heating value of the product fuel peat per unit weight;
- it enhances the transportability, handling and storage characteristics of the product peat fuel.

A disadvantage of thermal treatment is that it produces an effluent which requires expensive treatment in order to render it safe for discharge.

This report evaluates the technical and economic parameters of four technologies using thermal treatment for producing fuel peat. These are:

- JP-Energy
- ORF-Wetox
- Zimpro - Wet Oxidation and Wet Carbonization
- Koppelman

In addition, technical reports are included on wet carbonization studies at the Institute of Gas Technology, and on a low severity approach developed jointly by Sherbrooke University and the National Research Council of Canada. Work done in Finland by the Technical Research Centre (VTT) on combined system studies including thermal treatment is also reported.

The importance of good heat exchanger performance and economics in the preheating of raw peat slurries has been emphasized, and existing information on the subject has been reviewed.

.4 Effluent Treatment

Treatment of liquid effluents and sludge from the wet oxidation or carbonization of peat slurries is considered necessary prior to their discharge. Data available about the quality of the effluents has been presented in this report along with specific costs of treatment derived from economic data received from JP-Energy/Wheelabrator-Frye and from the Ontario Research Foundation. These specific costs are considered to be indicative only. Definitive costs of effluent treatment can only be established in relation to limits specified by environmental safety regulations, which at present are not well defined and differ considerably from place to place.

.5 Cost of Feedstock

The technology and cost of mining and delivering peat to dewatering plants is outside the scope of this study. However, economic analysis of wet mining and slurry delivery operations at two levels of production capacity have been prepared on the basis of data provided by JP-Energy/Wheelabrator-Frye and by Valmet-Vapo International.

.6 Modular Plant Ratings

Both the technical and economic consequences of modularization have been addressed. Technical optimization of unit sizes of key equipment dictates optimum modular ratings for dewatering plants. In some cases optimum design and cost considerations limit size. In such cases, when increased plant production capacity is desired, multiple unit modules must be set up in parallel. Both the Wetox and Zimpro processes are modular in this sense, at about 25,000 dry tonnes per year capacity. Filter presses are available in stepped modular ratings, the smaller modules producing about 30,000 dry tonnes per year and the larger modules about 70,000 dry tonnes per year. On the other hand, the JP-Energy process plant trains are custom designed through a range of production ratings from about 100,000 to about 300,000 dry tonnes per year. The Carver-Greenfield peat drying system has been analyzed at about 250,000 dry tonnes per year, but would also be custom designed and optimized for any desired plant production rating.

The Valmet-Vapo process is modularized at about 5,000 dry tonnes per year, but has been cost analyzed at 17,500 dry tonnes per year by using a group of stage one and stage two dryers (since VVI provided their economic data to us on the latter basis).

In general:

- Multiples of small modules can be used to increase plant production capacity, but under such an arrangement economies of scale are limited to general plant, plant auxiliaries, and common services. However, they benefit from the advantage that very large changes in plant capacity may be effected without involving major redesign of process plant.

- Complex process trains, basically designed for large production capacities, are capital intensive and are designed to achieve optimum plant mass and energy balances. At their optimum ratings they achieve very economical production. Down-rating such plants may lose some of the economies of scale, and may involve major redesign of process equipment.

No attempt has been made in this study to change the modular ratings at which process technologies have been developed by their originators.

1.2 EXECUTIVE SUMMARY

SUBJECT REFERENCE

121 TECHNICAL OPTIONS

This study has evaluated the technical options available for dewatering and drying wet-mined peat for the purpose of fuel peat production. It is assumed that the feedstock will be a macerated peat slurry with a solids concentration ranging from 6% to 10%. Figure 1-1

A peat fuel plant may be composed of one or more of the following unit processes: Figures 2-1, 2-2, 2-3

- slurry storage at plant
- thermal treatment
- mechanical dewatering
- thermal drying
- effluent treatment
- densification

The first stage of dewatering to remove the bulk of water is generally carried out by mechanical equipment, such as filter presses. This method can reduce the original moisture content of 90wt% in "raw" bog peat to 70wt% in the filter cake, thus removing 74% of the original water in bog peat. Table 2.3-1

SUBJECT	REFERENCE
"Thermal treatment" processes have been developed in order to enhance the mechanical dewaterability of peat slurries, and to enable filter presses to reduce slurry moisture contents to 50wt%. Researchers in this field have found from experience that it is almost impossible to dewater "raw peat" slurries economically to less than about 70% by mechanical means. High loss of fines also contributes to the poor economics of this process. On the other hand, "thermally treated" slurries are claimed to dewater to 50% moisture content in filter presses, with lesser fines losses.	Part 2.3
Whereas pressate from the filtration of "raw" peat slurries is considered safe for return to the bog, pressates from the filtration of "thermally treated" peat slurries are considered unsafe for discharge without treatment. The economics of thermal treatment processes are adversely affected by the cost of effluent treatment.	Part 2.6
Further drying to reduce moisture contents below 50wt% is generally carried out in thermal dryers.	Part 2.5

122 TECHNICAL FEASIBILITY

There are no purely technical barriers to dewatering and drying wet-mined peat slurries. All the problems encountered relate to the cost-effectiveness of competing processes, and to determining the real performance and cost parameters of any specific technology. A few promising processes are currently at early stages of conceptual design. They have been technically evaluated by the study to the extent of data made available, but economic evaluation has not been possible where a level of pre-feasibility cost estimation has not been achieved. New process development is often based on novel applications or combinations of conventional technologies; in such cases no technical barriers need to be surmounted, but the cost effectiveness of the concept is a major consideration. In almost every case, the pace of new development has been adversely affected by the current stability in world energy prices.

The Analysis of Evaluation of this report briefly reviews the technical aspects of the various unit processes and discusses the technologies applicable to each unit process. Part 3 of the report contains detailed technical evaluations of all currently known technologies. Part 2

123 COST RELATIONSHIPS

An economic analysis in Part 2.7 provides a detailed review of the cost relationships between Table 2.7-1

SUBJECT	REFERENCE
comparable process units of competing technologies. All costs presented are battery limits processing costs, which exclude costs of feedstock and effluent return to bog. Costs are broken down per unit process for more pertinent comparison of competing technologies.	Figure 2-2
Confidence in the cost resultants presented by this study is of the order of (+)30%:(-)25%, which is about what would be expected of pre-feasibility estimates.	
However, a more important aspect of credibility than the accuracy of any particular cost figure is the relationship which each cost figure bears to independently derived costs for comparable unit processes. The analysis in Part 2.7 indicates how this relationship is supportive.	Part 2.7
Of the processes evaluated for dewatering and drying peat slurries from wet mined peat, that of JP-Energy is the most completely developed. The cost data from JP-Energy and Wheelabrator-Frye appears to be the most reliable. Again, it is not so much the absolute figures of cost which are considered reliable in themselves, as the relation which the JP-Energy costs bear to other independently derived cost figures.	Part 234.1

SUBJECT	REFERENCE
The Koppelman K-fuel process consists of a modular train of equipment which produces a peat fuel from relatively dry, 50wt% moisture content, peat. It is the only process of its type, and it is therefore difficult to relate its costs to the costs of other processes. However, the K-fuel cost figures may well be the most accurate of all, because they are compiled from the fabrication and construction contracts of a demonstration plant which is already under construction.	Part 234.2
The Zimpro and ORF-Wetox wet oxidation processes are both modular, at around 25,000 dry tonnes per year, and their level of development is about the same. The cost relationship between them is supportive.	Part 233
All four of the above processes thermally treat the peat in order to enhance mechanical dewatering.	
Conventional filter press technology has been cost estimated for dewatering treated and untreated peat slurries. Cost estimates have also been prepared for conventional thermal drying systems.	Part 2.4 Part 2.5
Three entirely new developments, all of which dewater untreated wet-mined peat slurries, are reported and their costs analyzed:	

SUBJECT	**REFERENCE**
- Valmet-Vapo-International (VVI)	Parts 2.4 & 2.5
- Sulzer	Part 2.4
- Carver-Greenfield	Part 2.5

These processes have been developed recently, and their cost estimates may accordingly be subject to wider variation. However, it should be relatively easy to verify the claims made in each case. If they do fulfill expectations, the VVI and Sulzer technologies would both constitute breakthroughs in dewatering peat slurries without the pollution hazard of thermal treatment. The Carver-Greenfield process is not as attractive cost-wise, but is a potential contender if the first two should falter, or if thermal treatment processes should increase in cost.

124 SELECTED COST COMPARISONS

From the Economic Analysis of Part 2.7 the following items are selected for summary cost comparison: Table 2.7-1

Basis A
- Plant rating: less than 50,000 dry tonnes per year of product
- Product fuel: 50% M.C. peat
- Feedstock: wet-mined raw peat slurry

SUBJECT		REFERENCE

Process	Cost of Production C$ Per D.T. of Product	
		Table 2.7-1
VVI	76.91	Item G
Sulzer	64.12	Item H

Basis B - Plant rating: above 200,000 dry tonnes per year of product
- Product fuel: 10% M.C. or less
- Feedstock: wet-mined raw peat slurry

Process	Cost of Production C$ Per D.T. of Product	
		Table 2.7-1
JP-Energy	97.67	Item M
Carver-Greenfield	118.36	Item P

Basis C - Plant rating: ORF and Zimpro at 25,000 DTPY and JP-Energy at 270,000 DTPY
- Product fuel: thermally treated slurry
- Feedstock: wet-mined raw peat slurry

SUBJECT REFERENCE

Process	Cost of Production C$ Per D.T. of Product	Table 2.7-1
ORF-Wetox	84.65	Item F
Zimpro	92.00	Item E
JP-Energy	49.00	Item I

It must again be emphasized that the cost relationships described are of greater significance than the costs themselves. For example, when comparing BASIS A and BASIS B, the former product is at 50% M.C. and the latter at 10%, so they are not directly comparable.

Part 2.7

125 R&D REQUIREMENTS

R&D effort is required in the following areas:

- Preheating of cold peat slurries. This may be done either by indirect heat exchange with other process streams or by direct injection of steam into the cold peat slurry (the steam having been generated by utilizing waste process heat).

SUBJECT	REFERENCE
- Pumping and pipelining of macerated peat slurries.	
- Front end dewatering of pumpable raw peat slurries (at 6% to 10% solids) prior to or during mechanical dewatering in filter presses, with and without the use of polyelectrolytes/flocculents. Objective: high output with low fines loss during dewatering.	
- The technology and economics of treating effluents from thermal treatment of raw peat slurries.	

1.3 RECOMMENDATIONS

Recommendations arising from this phase of the study can be divided into two main categories:

- recommendations for review of opportunities for design and construction of a demonstration plant;
- recommendations for front end investigation of selected process options for a demonstration plant.

131 OPPORTUNITIES FOR DESIGN AND CONSTRUCTION OF A DEMONSTRATION PLANT

Selection of technologies suitable for a demonstration plant will be influenced by key factors, including:

- assessed quantity and quality of commercially exploitable fuel peat in selected deposits;
- end product(s) established by market study;
- size of demonstration facility determined by extent of deposits and marketability of product(s).

Some provinces have assessed selected fuel peat deposits and are reviewing them for exploitation to produce solid, liquid or gaseous fuel products. Where such planning includes review of the wet-mining option it can reasonably be expected that dewatering would constitute a component unit of the fuel plant. Therefore, an opportunity for a demonstration peat dewatering facility may exist within the context of current and projected provincial energy planning. Such prospects may exist even in those provinces where natural gas is freely available. In provinces where natural gas is not likely to be available for some time, peat could be a viable energy resource particularly in areas where biomass is not available as an energy alternative to oil. A small facility to demonstrate wet mining, dewatering and drying, and to produce a fuel alternative to oil would receive favourable consideration.

Based on plant capacity in dry tonnes per year and on desired moisture content in the product fuel, the following process options should be reviewed for dewatering and drying wet-mined peat slurries:

PROCESS OPTIONS FOR PLANT CAPACITIES OVER 100,000 DTPY

Item	Desired M.C. in the Product Fuel	Unit Process Combinations	Technology/Equipment Supplier Name(s)
1	Dry to 35%	Slurry Storage Thermal Treatment Mechanical Dewatering Thermal Drying	JP-Energy
		Effluent Treatment	(*)
2	Dry to 35%	Slurry Storage	
		Steam Drying	Carver-Greenfield
		Effluent Treatment	(*)
3	Dry to 35%	Slurry Storage	
		Mechanical Dewatering	Sulzer/Larox/ others

PROCESS OPTIONS FOR PLANT CAPACITIES OVER 100,000 DTPY

Item	Desired M.C. in the Product Fuel	Unit Process Combinations	Technology/Equipment Supplier Name(s)
3 (Cont'd)		Thermal Drying	Outokumpu/Chalmers/ Carver-Greenfield/ M-E-C/Heil/others
		Effluent Treatment	(*)
4	50%	Slurry Storage	
		Thermal Treatment	JP-Energy
		Mechanical Dewatering	
		Effluent Treatment	(*)
5	50%	Slurry Storage	
		Mechanical Dewatering	Sulzer
6	50%	Slurry Storage	
		Mechanical Dewatering	Sulzer/Larox/ others
		Steam Drying	Chalmers/ Carver-Greenfield
		Effluent Treatment	(*)

PROCESS OPTIONS FOR PLANT CAPACITIES UP TO 100,000 DTPY

Item	Desired M.C. in the Product Fuel	Unit Process Combinations	Technology/Equipment Supplier Name(s)
1	Dry to 35%	Slurry Storage	
		Thermal Treatment	- ORF-Wetox/Zimpro
		Mechanical Dewatering	- Sulzer/Larox/ others
		Thermal Drying	- Chalmers/Outokumpu/ M-E-C/Heil/others
		Effluent Treatment	- (*)
2	Dry to 50%	Slurry Storage	
		Mechanical Dewatering	- VVI
		Thermal Drying	
3	50%	Slurry Storage	
		Mechanical Dewatering	- Sulzer
4	50%	Slurry Storage	
		Thermal Treatment	- ORF-Wetox/Zimpro
		Mechanical Dewatering	- Sulzer/Larox/ others
		Effluent Treatment	- (*)
5	50%	Slurry Storage	
		Mechanical Dewatering	- Sulzer/Larox/ others

PROCESS OPTIONS FOR PLANT CAPACITIES UP TO 100,000 DTPY

Item	Desired M.C. in the Product Fuel	Unit Process Combinations	Technology/Equipment Supplier Name(s)
5 (Cont'd)		Thermal Drying	- Chalmers/Outokumpu/ M-E-C/Heil/others
		Effluent Treatment	- (*)

* Anaerobic and aerobic digesters can be custom-designed for this application by a number of suppliers. ORF have reviewed a design developed by National Research Council Canada, and JP-Energy have reviewed a large number of commercial designs. Effluent quality from steam drying of peat is not known and would need to be established in order to determine whether treatment of steam dryer effluent is necessary.

Although data presented in this report evaluates JP-Energy and Carver-Greenfield processes at production capacities in excess of 100,000 dry tonnes per year, they may both be capable of providing economical production from plants of lower capacities. This should be investigated as recommended in Part 132.

The K-Fuel process is not listed because its present design is suitable for 50% M.C. feedstock rather than for wet-mined peat slurries.

A basic process to suit the desired end product would be selected from those suggested above and so combined with other unit processes that target quality is achieved at lowest product cost.

Conceptual plant design and feasibility studies would precede detail engineering and plant construction when the above preliminaries have been resolved.

132 FRONT END INVESTIGATION OF PROCESS OPTIONS FOR A DEMONSTRATION PLANT

It is recommended that, in parallel with conducting a search to determine suitable peat deposits and end product(s) for a demonstration plant as outlined in Part 131, the following actions be taken to further investigate process options.

- Review the R&D requirements listed in Part 125, under Executive Summary, and determine what R&D effort is warranted in the context of planning for a demonstration plant.

- Investigate the status and development details of the VVI peat drying system, witness operation of their demonstration plant, and provide Canadian peat samples for testing. Determine commercial conditions, performance warranties and time frame for supply of a plant to a Canadian demonstration project.

- Investigate the development details of the Sulzer peat dewatering system, attend and witness pilot plant testing with Canadian peat samples. Determine commercial conditions, performance warranties and time frame for supply of a plant to a Canadian demonstration project.

- Evaluate the economics of steam drying by the Chalmers University process in cases where back pressure, extraction or process steam is available, and review effluent quality to establish the need for treatment.

- Obtain data and technically evaluate the Carver-Greenfield peat drying system. Investigate the economics of C-G process plants for capacities lower than 100,000 dry tonnes per year. Supply Canadian fuel peat samples for testing to determine major process and plant design parameters, and witness testing. Determine commercial conditions, performance warranties and time frame for supply of a plant to a Canadian demonstration project.

- Investigate the economics of JP-Energy process plants for production capacities below 100,000 dry tonnes per year.

- Determine commercial conditions, performance warranties and time frame for supply of an ORF-Wetox plant to a Canadian demonstration project.

- Determine commercial conditions, performance warranties and time frame for supply of a Zimpro plant to a Canadian demonstration project.

- Establish the possibility of designing and constructing a matching wet-mining operation in parallel with the fuel plant in order that the feedstock for the fuel plant will be available when required.

PART 2

ANALYSIS OF EVALUATION

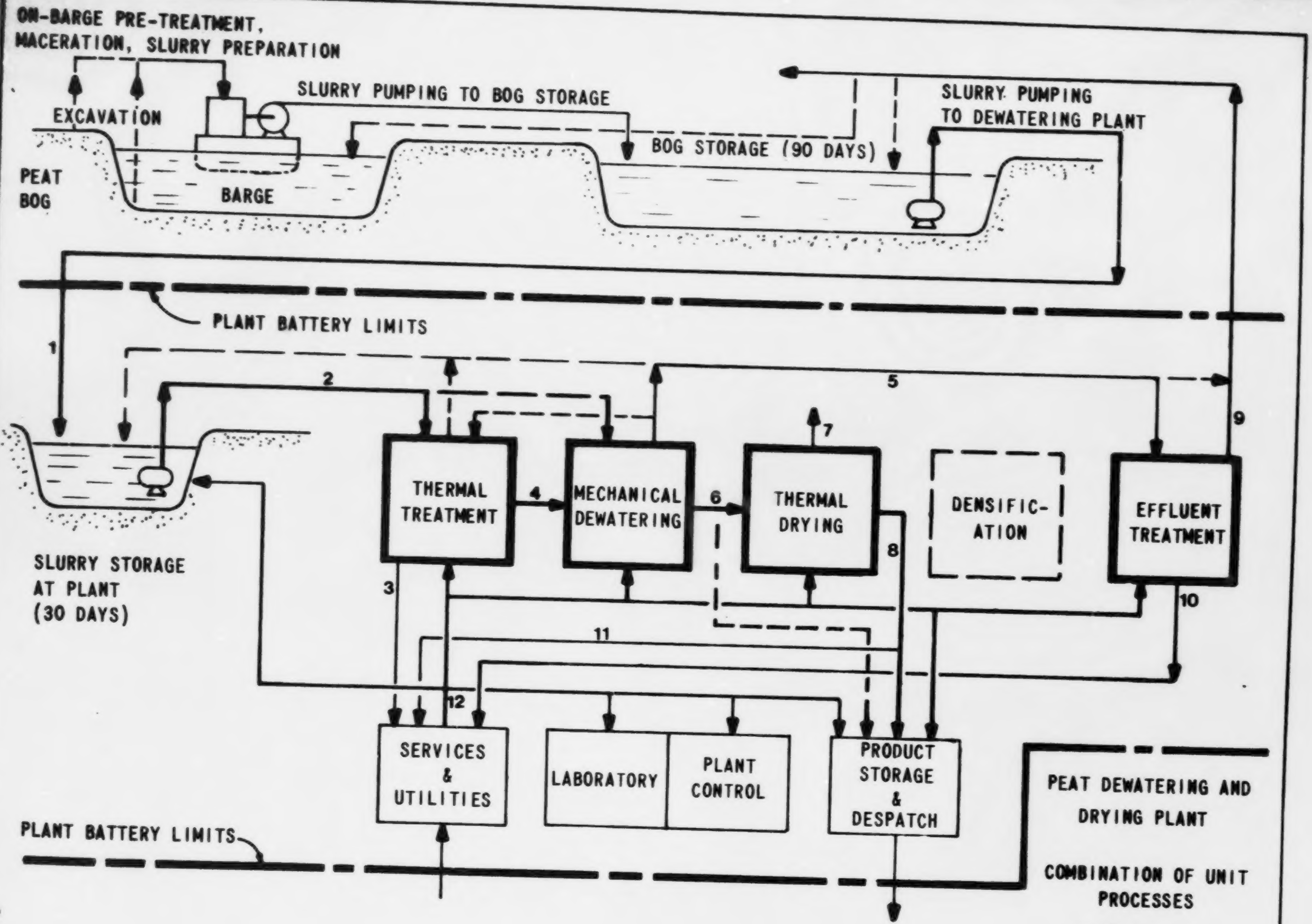
2.1 SCOPE AND PROCEDURE

The Scope of this study is indicated by the plant battery limits shown on Figure 2-1. The unit processes shown within the battery limits, except densification, have been individually evaluated in Part 3 of the report. Densification, as a unit process, is illustrated in broken lines on Figure 2-1 to indicate that, while it properly constitutes a unit process in a plant producing peat fuel, it has not been investigated because pelletizing and briquetting are already well developed and commercially marketed processes.

The analysis which follows discusses the main findings of the evaluations reported in Part 3 by reviewing the technology and economics of each unit process shown on Figure 2-1. Figures 2-2 and 2-3 show alternative combinations of unit processes in a plant.

The discussion follows the sequence:

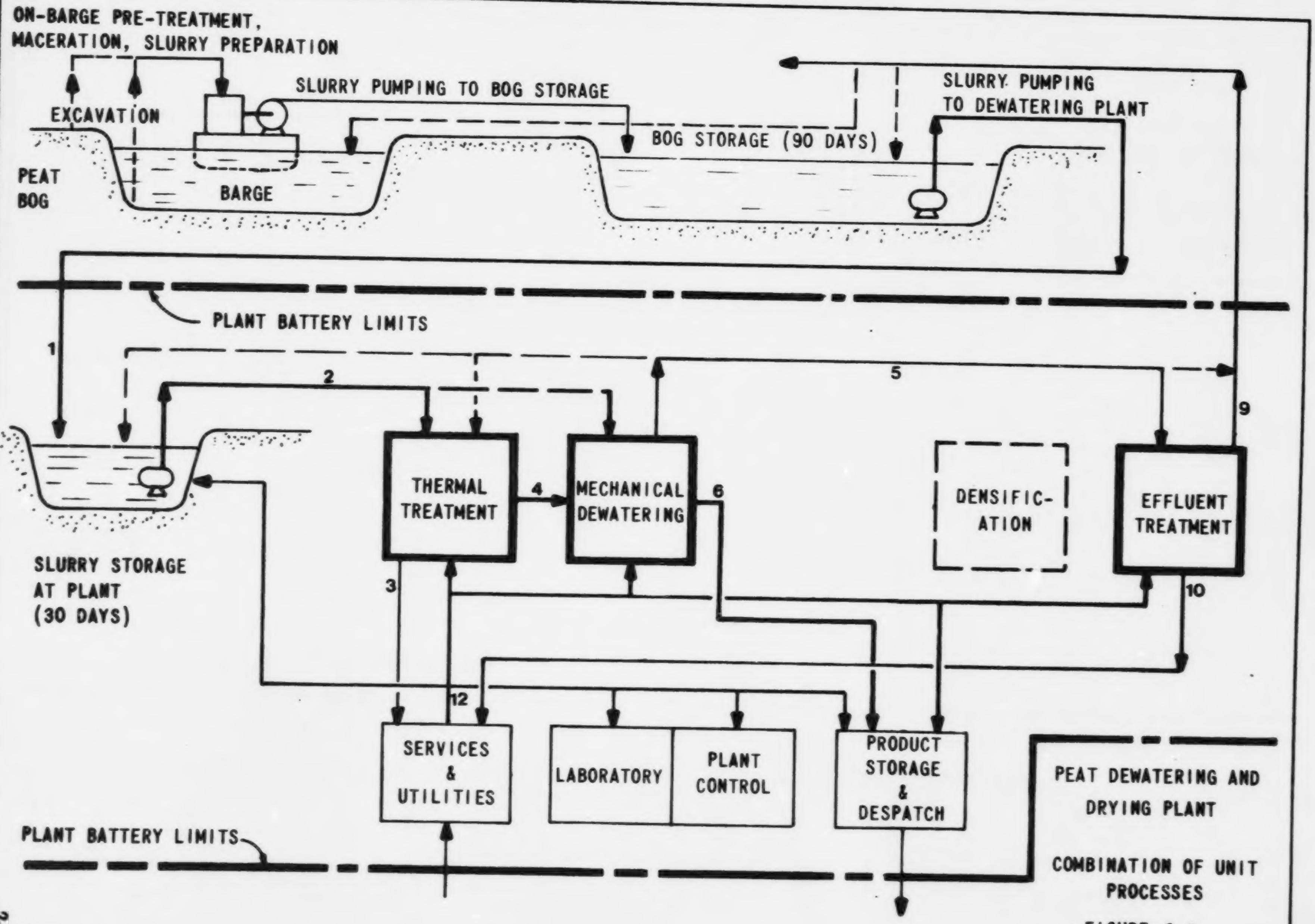
- Part 2.2: Slurry Storage at the Dewatering Plant
- Part 2.3: Thermal Treatment Systems
- Part 2.4: Mechanical Dewatering Systems
- Part 2.5: Thermal Drying Systems
- Part 2.6: Effluent Treatment and Environmental Consideration
- Part 2.7: Economic Analysis
- Part 2.8: Feedstock Requirements and Costs


ON-BARGE PRE-TREATMENT,
MACERATION, SLURRY PREPARATION
EXCAVATION
SLURRY PUMPING TO BOG STORAGE
PEAT
BOG
BARGE
BOG STORAGE (90 DAYS)
SLURRY PUMPING
TO DEWATERING PLANT
PLANT BATTERY LIMITS
1
2
3
4
5
6
7
8
9
10
11
12
SLURRY STORAGE
AT PLANT
(30 DAYS)
THERMAL
TREATMENT
MECHANICAL
DEWATERING
THERMAL
DRYING
DENSIFIC-
ATION
EFFLUENT
TREATMENT
SERVICES
&
UTILITIES
LABORATORY
PLANT
CONTROL
PRODUCT
STORAGE
&
DESPATCH
PLANT BATTERY LIMITS

PEAT DEWATERING AND
DRYING PLANT

COMBINATION OF UNIT
PROCESSES

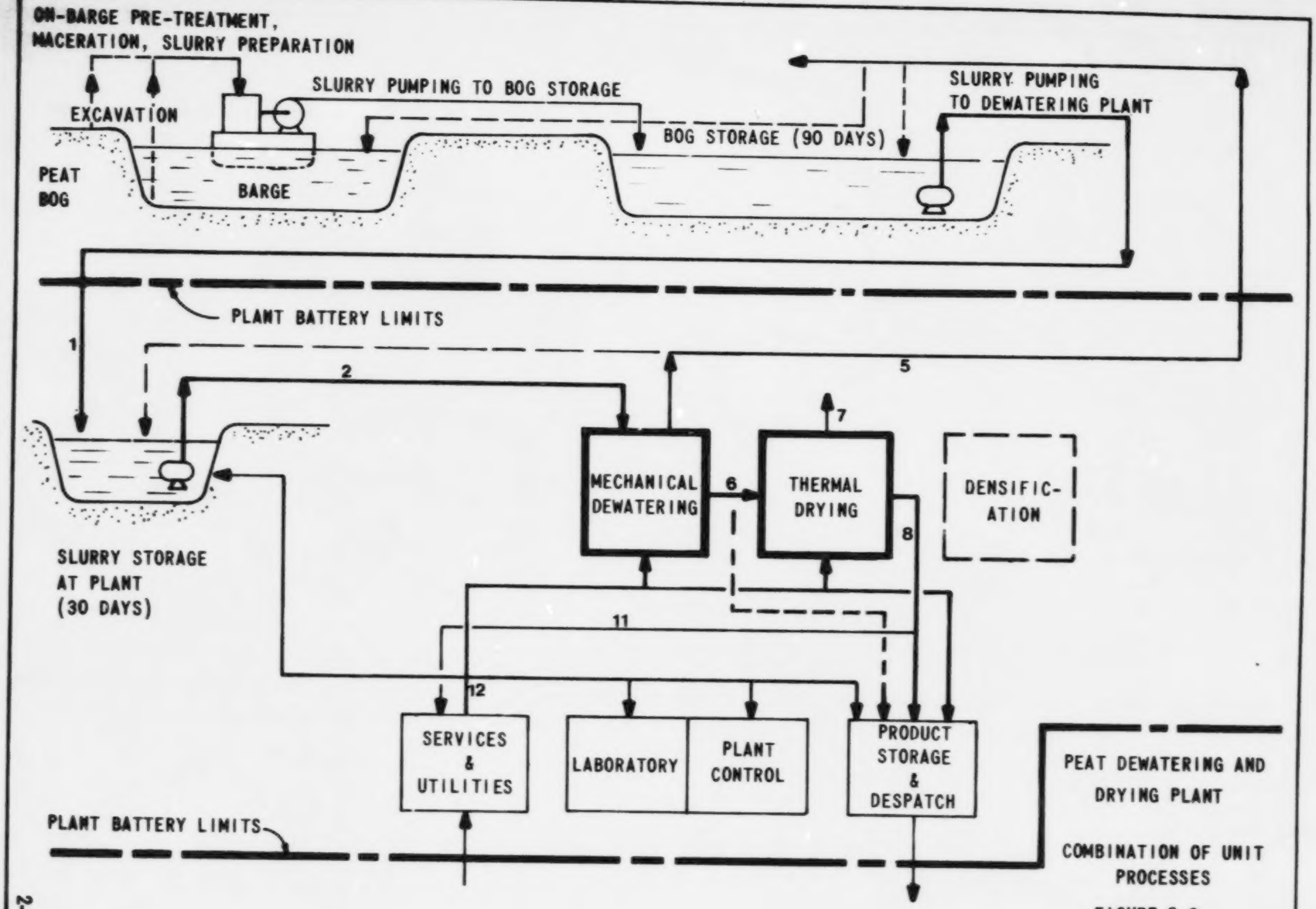
FIGURE 2-1


ON-BARGE PRE-TREATMENT,
MACERATION, SLURRY PREPARATION
EXCAVATION
SLURRY PUMPING TO BOG STORAGE
PEAT
BOG
BARGE
BOG STORAGE (90 DAYS)
SLURRY PUMPING
TO DEWATERING PLANT
PLANT BATTERY LIMITS
1
2
5
9
SLURRY STORAGE
AT PLANT
(30 DAYS)
THERMAL
TREATMENT
4
MECHANICAL
DEWATERING
6
DENSIFIC-
ATION
EFFLUENT
TREATMENT
3
10
12
SERVICES
&
UTILITIES
LABORATORY
PLANT
CONTROL
PRODUCT
STORAGE
&
DESPATCH
PLANT BATTERY LIMITS

PEAT DEWATERING AND
DRYING PLANT

COMBINATION OF UNIT
PROCESSES

FIGURE 2-2


ON-BARGE PRE-TREATMENT,
MACERATION, SLURRY PREPARATION
EXCAVATION
SLURRY PUMPING TO BOG STORAGE
PEAT
BOG
BARGE
BOG STORAGE (90 DAYS)
SLURRY PUMPING
TO DEWATERING PLANT
PLANT BATTERY LIMITS
1
2
5
MECHANICAL
DEWATERING
6
THERMAL
DRYING
7
8
DENSIFIC-
ATION
SLURRY STORAGE
AT PLANT
(30 DAYS)
11
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SERVICES
&
UTILITIES
LABORATORY
PLANT
CONTROL
PRODUCT
STORAGE
&
DESPATCH
PLANT BATTERY LIMITS

PEAT DEWATERING AND
DRYING PLANT

COMBINATION OF UNIT
PROCESSES

FIGURE 2-3

2.2 SLURRY STORAGE AT THE DEWATERING PLANT

This section presents first order estimates developed by Monenco for peat slurry storage at a dewatering plant.

While wet mining technologies and the transport of wet-mined peat to the processing plant are outside the scope of this study, it was nevertheless considered essential to review the state-of-the-art of wet mining systems and costs in order to ensure that the assumptions made with regard to feedstock are reasonable and are based on current information. Part 2.8 of this report is devoted to a brief review of wet mining systems and their costs. The review concludes that, at the present time, there is a preponderance of opinion in favour of supplying a macerated peat slurry to a slurry storage basin at the dewatering plant. The weight percent of dry solids of which such a slurry should be composed is open to discussion. However, since most dewatering technologies appear to consider a pumped peat slurry to be the most suitable feedstock for their equipment, no alternative form of incoming feedstock has been considered for the purposes of this investigation.

It is recognized that some processes will accept feedstock at lesser solids concentrations and some at greater solids concentrations. Nevertheless the size, capacity, pumping cost and capital investment for the slurry storage at plant site are estimated in Tables 2.2-1 and 2.2-2 on the basis of 8% solids concentration in the slurry.

At the dewatering plant slurry is delivered into a storage basin, which this study has assumed will store the equivalent of 30 stream days of plant capacity. Cost estimates and specific costs of plant slurry storage and pumping systems have been prepared for ratings of dewatering plants equivalent to 25,000, 100,000 and 300,000 dry tonnes of peat fuel per year.

In this study the slurry storage and pumping system at the dewatering plant has been treated as the first unit process in the plant for the following reasons:

- A measure of independence from problems at the bog is essential for continuity of plant operation, particularly in the winter.

- Control of solids concentrations in the feedstock is important for optimum operation of the dewatering plant. It is expected that fine control cannot be exercised in this regard in bulk mining and storage operations at the bog, whereas good design of a storage basin at the plant can provide the necessary measure of control for slurry solids concentration input to the dewatering plants.

- Zimpro's studies indicate that effluent recycling beneficially affects the degree of solids solubilization during thermal treatment. The slurry storage basin at the plant would assist in such recycling.

- In plants where thermal treatment is involved anaerobic/aerobic treatment of effluent is required to render it safe for discharge. Any breakdown in the effluent treatment system which cannot be corrected within a limited time could result in enforced plant outage. The slurry storage basin could, in such cases, act as a temporary reservoir for untreated effluent.

- Even under severe winter conditions it may be economically possible to keep the slurry storage basin at the plant in operation by cycling plant waste heat to the basin, or perhaps even by building the storage under the plant, thus protecting it from winter ambients.

All these considerations make slurry storage at plant an essential unit process of the dewatering plant.

TABLE 2.2-1

Estimates of Slurry Storage and Pumping System Costs at Dewatering Plant Computed for Three Levels of Plant Production Capacity

		Dewatering Plant Production Capacity @ 7500 hrs/yr		
		25,000 DTPY	100,000 DTPY	300,000 DTPY
1.	Slurry Concentration	8% dry solids	8% dry solids	8% dry solids
2.	Storage Capacity for 30 Stream days	40,000 Tonnes	160,000 tonnes	470,000 tonnes
3.	Pumping Design Capacity	55 TPH	220 TPH	650 TPH
4.	Pumping Distance to Plant	200 m	200 m	200 m
5.	Slurry Basin Size with 10 m depth	40 m x 100 m	100 m x 160 m	220 m x 250 m
6.	Static Head for Submersible pump	10 m	10 m	10 m
7.	Pipe diameter	200 mm	350 mm	600 mm
8.	Pumping Power	15 kW	30 kW	60 kW
9.	Capital investment - Slurry Basin - Pump, Pipeline and Power Supply	 $300,000 $ 20,000	 $1,125,000(1) $ 35,000	 $2,000,000 $ 60,000
10.	Cost of Power @ $0.05/kWh	$0.75/hr	$1.50/hr	$3.00/hr
11.	Operating Cost/ Dry Tonne (2)	$2.624	$2.163	$1.275
12.	Operating Cost/GJ @ 20 GJ/T (2)	$0.130	$0.108	$0.064

(1) Poly-lined basin cost. Clay-lined basin is estimated at $760,000.
(2) See Table 2.2-2.

TABLE 2.2-2
COST OF 30 DAYS SLURRY STORAGE AND PUMPING TO DEWATERING PLANT
1983 CDN DOLLARS

No.		Units	PLANT CAPACITY ON DRY TONNE BASIS 25,000 Tonnes/yr	50,000 Tonnes/yr	100,000 Tonnes/yr	300,000 Tonnes/yr
1.	Capital Investment	$	320,000	0	1,160,000	2,060,000
2.	Annual Capital Charges (CRF for 20 yrs @ 15% = 0.159761)	$/yr	50,000	0	185,000	330,000
3.	Annual O&M Costs	$/yr	10,000	0	20,000	30,000
	Fixed Annual Cost	$/yr	60,000	0	205,000	360,000
4.	Annual Variable Costs	$/yr	5,600	0	11,250	22,500
	Total Annual Costs	$/yr	65,600	0	216,250	382,500
5.	Cost/Weight (dry basis)	$/tonne	2.624	0.00	2.163	1.275
6.	Cost/Energy @ 20 GJ/dry tonne raw peat	$/GJ	0.130	0.00	0.108	0.064

Notes:

Item 3 Automatic unattended systems are assumed. Annual maintenance and interim replacement costs are assumed at 3%, 1.7%, 1.5% respectively for 25,000/100,000/300,000 dry tonne/yr plants.

Item 4 Costs = pump kW rating x 7500 hrs/yr x $0.05/kWh

2.3 THERMAL TREATMENT SYSTEMS

A brief discussion of thermal treatment technologies is presented below. In order to avoid an excess of repetition the discussion often assumes reader familiarity with Part 3 of this report, which contains detailed evaluations of each of the processes discussed.

All thermal treatments subject the raw peat slurry to heat under pressure with the object of freeing the water which is bound in the colloidal and micropore structure of the peat. The treatment also changes the colloids so that they are retained in the filter cake instead of passing through and being lost in the filtrate. It should be noted that "thermal treatment" merely 'cooks' the peat slurry. It does not dewater or dry it and is quite different from "thermal drying" which extracts moisture from the peat by the application of heat.

231 OBJECT OF THERMAL TREATMENT

This study investigated alternative technologies for thermal treatment of raw peat slurries. All thermal treatments perform the function of destroying the hydrophilic nature of raw peat, by breaking down the inherent water-bonding structures. They are, therefore, treated in this summation as comparable unit processes.

The object of thermal treatment is to reduce the overall cost of peat dewatering. 100 kg of raw peat extracted from the bog typically contains 90 kg of water and 10 kg of peat solids (dry basis). Since in current practice the maximum average weight percent moisture content at which peat is used as a fuel is 50%, 80 kg of water must be removed from 100 kg of raw peat. It has been found that, whereas raw peat cannot be dewatered to much below 70% moisture content by mechanical filtration, thermally treated peat can be dewatered to 50% moisture content by the same filtration equipment. The water removal required for various end uses of fuel peat is shown in Table 2.3-1. It can be seen that, per 100 kg of raw peat, about 80 kg, or almost 90%, of water, must be removed to produce a fuel peat at 50% moisture content, which is then suitable for combustion. A further 4.5 kg water, equal to 5% of the original water, must be removed to produce a 35% moisture content fuel suitable for gasification. In order to reduce the moisture content to 10% for densification, a further 4.28 kg, equivalent to 4.8% of the original moisture content, must be removed.

It has been variously estimated that, depending on the system used, the heat required for thermal dewatering can range from 500 kJ to 4,000 kJ per kilogram of water removed. Therefore, if 80 kg of water must be removed from 100 kg of 90 wt.% moisture content raw peat by thermal drying alone, the heat input would range between 40,000 kJ and 320,000 kJ. The resulting fuel would have 10 kg dry solids with a heating value of 200,000 kJ. It is evident that dewatering raw peat by thermal drying only would consume a large enough proportion of the fuel peat to make the process energy-inefficient.

Mechanical systems such as centrifuging and filtration are most likely to be used in the earlier stages of dewatering, where the bulk of the water has to be removed. It has been demonstrated that mechanical filtration systems will dewater raw peat to about 70% moisture content with about 4% loss of fines. The same systems will dewater "thermally treated" peat to 50% moisture content with the same or lesser fines losses. Table 2.3-1 shows that the difference between 70% moisture content and 50% moisture content is about 13 kg of water per 100 kg of raw peat. If, by upstream thermal treatment, this

TABLE 2.3-1

Water Removal from Raw Peat for Various End Uses

	Material/ Product	Moisture Content	End Use for Which Typically Suitable	Total Wt. Before Dewatering kg	Product Composition from 100 kg Original Wt. of Raw Peat		Remaining Total Weight kg	Water Removed kg	Percentage of Original Water Removed %
					Water kg	Solids kg			
1.	Raw Peat	90	-	100	90.00	10.00	-	-	-
2.	Mechanically Dewatered Peat	70	-	100	23.33	10.00	33.33	66.67	74.1
3.	Peat Fuel	50	Combustion	100	10.00	10.00	20.00	80.00	88.9
4.	Peat Fuel	35	Gasification	100	5.38	10.00	15.38	84.62	94.0
5.	Peat Fuel	10	Densification (Pelletizing/ Briquetting)	100	1.10	10.00	11.10	88.90	98.8

additional 13 kg of moisture can be removed in the same mechanical presses, then it saves that much water from removal by the less energy efficient downstream process of thermal drying. (The distinction between "thermal treatment" and "thermal drying" has been described earlier in this Part.) It is claimed that thermal treatment decreases the cost of downstream processing and thereby reduces the overall cost of dewatering raw peat from a typical 90% moisture content in raw peat to less than 50% moisture content in peat fuel.

Where large quantities of primarily free water have to be removed from very wet material, mechanical systems will remove a major proportion of the water at a fraction of the cost of thermal systems. When the moisture content has been reduced to 50% or less, mechanical pressing will remove very little more. The moisture content may then be more economically reduced by thermal drying to levels suitable for gasification or densification.

232 TYPES OF THERMAL TREATMENT

Thermal treatments fall into two main categories, as shown in Table 2.3-2. Those with air or oxygen injection are termed wet oxidation, while those without are termed wet carbonization. All have been individually reviewed in Part 3 of this report, the evaluation being based on the information provided by the process/concept developer.

TABLE 2.3-2

Types of Thermal Treatment Processes and Concepts

	Thermal Treatment Processes and Concepts	Type of Thermal Treatment	
		Wet Oxidation (With Injection of Air or Oxygen)	Wet Carbonization (Without Injection of Air or Oxygen)
1.	JP-Energy Process		X
2.	Koppelman process		X
3.	Sherbrooke/NRC Low Severity Approach		X
4.	Wetox Partial Oxidation Process	X	
5.	Zimpro Low Pressure Partial Oxidation Process	X	
6.	Zimpro Wet Carbonization Process (termed "Heat Treatment" by Zimpro)		X
7.	IGT Wet Carbonization Studies		X

Both wet oxidation and wet carbonization processes heat peat slurry under pressure and break down the water-bonding structures. The decarboxylation and water removal reactions reduce the chemically bonded oxygen and nitrogen contents of the original peat. This enhances the heating value on a unit weight basis. Concurrently there is some loss of feed carbon, which is converted to gases and water-soluble organics.

The difference between wet oxidation and wet carbonization lies in the heat source. The former process attains autothermal balance in the reactor by using heat generated internally by the wet combustion of a part of the feedstock. The latter process uses heat provided to the reactor from an external source, which could be a steam generator using a part of the product peat fuel to generate steam.

A major factor in the successful implementation of any wet oxidation/carbonization process is the economical preheating of raw peat slurries.

These slurries foul and corrode heat transfer surfaces. Although high alloy metals can be used to prevent heat exchanger corrosion, fouling of the surfaces reduces heat transfer coefficients and increases equipment costs. The technical problems which this poses are reflected in the economics of the processes.

233 DISCUSSION OF WET OXIDATION PROCESSES

Although the partial wet oxidation processes of ORF and Zimpro treat the raw peat in the same basic manner, the philosophy behind the two designs is different and is reflected not only in the types of equipment used but also in the yields of product obtained.

Parts 323 and 324 of this report contain detailed evaluations of two partial wet oxidation processes for peat slurry feedstocks:

- the Wetox process, developed by Ontario Research Foundation (ORF) of Mississauga, Ontario, Canada, and
- the Zimpro process, developed by Zimpro Inc. of Rothschild, Wisconsin, U.S.A.

In 1982 ORF prepared a report on wet oxidation of peat for the National Research Council of Canada, which was issued in December 1982. During the same period Zimpro prepared a report for the U.S. Department of Energy on their process for wet oxidation of peat, which was issued in January 1983.

Figures 2.3-1 and 2.3-2 show the flow diagrams of the Wetox and Zimpro wet oxidation processes.

The Zimpro process employs a bank of stainless steel tubular heat exchangers to recover the sensible heat from the reactor effluent and uses it to preheat the feed slurry. As indicated in the Zimpro study, the cost of these exchangers is quite significant and, in fact, was the major factor influencing the choice of the optimum case. The question of potential fouling of heat transfer surfaces was not addressed, perhaps due to Zimpro's familiarity with these exchangers in sewage handling, an application believed by Zimpro to be similar to peat slurry handling.

On the other hand, ORF chose to avoid the use of heat exchangers for preheating the raw peat slurry in the belief that serious fouling of the heat transfer surfaces would be inevitable. In place of indirect heat transfer, the ORF design employs the direct injection of steam into the cold feed slurry to raise its temperature close to that of the reactor. The steam is generated in a waste heat boiler using the hot reactor effluents. Although steam injection avoids any potential fouling problems, the scheme has several significant consequences:

- In order to raise the necessary steam in the waste heat boiler, a larger proportion of the peat must be oxidized (ORF 10.7% versus Zimpro 3%), thus decreasing the yield of product and increasing the power requirement of the air compressor.

- Because of the diluting effect of the added steam, the solids concentration in the reactor is lowered. Thus, for a given plant capacity, either a larger reactor must be employed or, since the reactor size is limited to a maximum throughput of 50 wet tonnes/hour, each reactor must be derated and a larger number of parallel streams used to achieve a desired capacity.

ORF's report recognizes that these consequences arise from their assumption that a hot liquid effluent is likely to cause less fouling than is a cold slurry when either is in contact with a hot metal surface. For the heat exchange in the waste heat boiler, ORF have used a conservative overall heat transfer coefficient of 57 w/m^2-°C (10 Btu/hr-ft^2-°F). Zimpro have used 1306 w/m^2-°C (230 Btu/hr-ft^2-°F) as the overall heat transfer coefficient in their heat exchangers (given in a personal communication). JP-Energy have designed a special heat exchanger, using a rotating tube bundle for first stage heating of the feedstock and considerable work has been done in testing this heat exchanger. Performance data is proprietary at this time but, since it is an optimally designed heat exchanger for this application, the overall heat transfer coefficient may be closer to the one used by Zimpro than the one used by ORF.

Since heat exchangers constitute a major element of capital cost it is important to arrive at reliable performance factors for their design and operation. They handle the bulk volume of process mainstream and therefore even marginal changes in their performance characteristics are likely significantly to influence the economics of production. The coefficient used by ORF is 23 times lower than that used by Zimpro.

Zimpro have reported on three types of thermal treatment of peat slurry (A, B, C):

A. Wet Carbonization (termed "Heat Treatment" by Zimpro)

This is a low severity thermal treatment which heats the peat slurry under pressure at 177°C (350°F) for 15 minutes reactor residence time, with no injection of air or oxygen.

B. Wet Oxidation

Wet oxidation tests in the presence of excess oxygen were conducted at low temperatures 177°C to 204°C (350°F to 400°F) with 5 to 30 minutes residence times, and at high temperatures 200°C to 300°C (392°F to 572°F) with 60 minutes residence time.

C. Partial Oxidation

Partial oxidation tests were conducted using limited oxygen inputs of 3%, 5% and 8% oxidation at 149°C (300°F) for 30 minutes and 177°C (350°F) for 15 minutes residence time. These percentages were based on oxygen charged compared to total peat autoclave oxygen demand as determined by complete oxidation of peat at 320°C for 90 minutes with a catalyst.

Both the Wetox and Zimpro thermal treatment units are modular in design at around 25,000 dry tonnes per year. This may curtail the benefits of scale they can achieve in expansion of plant capacity.

234 DISCUSSION OF WET CARBONIZATION PROCESSES

Table 2.3-2 shows that wet carbonization has been studied by JP-Energy, Koppelman, Sherbrooke/NRC, Zimpro and IGT. The discussion which follows comments on the status and major significance of each study. For detailed evaluations the reader is referred to Part 3 of this report.

.1 JP-Energy

Status

This process, for which the North American licencee is Wheelabrator-Frye, is offered commercially in plant ratings of 100,000 to 300,000 dry tonnes per year. Plans for construction of PDF plants in Sweden and U.S.A. have been drawn up, but the levelling-off of energy prices has delayed their materialization. Figure 2.3-3 presents a process flow diagram for a plant rated at 36 dry tonnes per hour (270,000 DTPY at 7500 stream hours per year).

The following commentary highlights significant features of the JP-Energy process plant.

Heating the Feedstock

Heat exchangers containing rotating tube bundles heat the incoming raw slurry. This is a proprietary design, which claims to reduce fouling of heat exchange surfaces and allow a consistently high overall heat transfer coefficient. Further heating of the raw peat slurry is carried out in a flash preheating tower of proprietary design. Part 233 has already discussed the significance, and the problems, of optimizing this part of all thermal treatment processes. JP-Energy may have an economic solution to this problem, as indicated by the favourable economics of their thermal treatment process.

Thermal Drying

The thermally treated peat slurry is then mechanically dewatered to 50% moisture content by conventional filter presses, and in this regard the JP-Energy process claims no advantage over its competitors. However, in the subsequent thermal drying step, where the moisture content is reduced from 50% to about 10%, the JP-Energy process uses in-plant energy effectively so that its economics of thermal drying are good. The thermal balances of the process are used to good effect by plant optimization.

Benefit of Scale

The major equipment of the JP-Energy process is not modular, and can be sized through a wide range to obtain significant benefits from economies of scale.

.2 Koppelman

Status

A demonstration plant rated at 22,750 dry tonnes per year is currently under construction in North Carolina and is expected to be commissioned by the end of 1983. Figure 2.3-4 is a flow diagram of the plant. A larger plant, designed for a production of 45,500 dry tonnes per year and optimized for improved total energy balance is shown in Figure 322-4. Based on operating experience with the simpler and smaller demonstration plant it is proposed to finalize design and market the larger plant commercially.

Feedstock

Plant performance data has so far been developed on the basis of 50% moisture content feedstock. The plant is expected to be able to accept slurried peat feeds, but it has yet to be tested with them. The process which was originally developed for dewatering lignites, can produce K-Fuel briquettes using lignite, peat or chipped wood as its feedstock.

Process Parameters and Equipment Design

It will be seen from Table 2.3-3 that the K-Fuel reactors must be designed to operate under comparatively more severe pressure and temperature conditions than the reactors of other thermal treatment processes. The reactors are of tubular design and the process materials are pressure transported through them as they undergo carbonization. Table 2.3-1 shows that the volume of feedstock to be handled will increase by many multiples when the process is applied to slurry feedstocks. When feedstock has 50% moisture content, 88.9% (80 kg per 100 kg raw peat) of the original moisture has already been removed. Hence the first stages of the process plant may undergo some redesign when five times more feedstock is handled in the form of a slurry at, for example, 90% moisture content. As presently designed the system is optimized for producing a dry, clean burning, densified, high calorific value fuel from good quality lignite, wood or peat at 50% to possibly even 70% moisture content.

.3 Sherbrooke/NRC Approach

Status

Laboratory studies have been conducted to develop this low severity approach, for which a conceptual flow diagram is given in Figure 325-1. A small process development unit has been designed, but not yet constructed.

Feedstock

A well prepared peat slurry feedstock, not containing material in excess of 2 mm particle size, will be suitable.

Distinguishing Features of the Approach

The main feature of the process is that high speed heating, compression and pressure release is effected at comparatively low severity in terms of combination of temperature, pressure and residence time (190°C, 4140 kPa, one minute). A shearing action of the release mechanism breaks down the hydrophilic structure of peat and permits efficient mechanical dewatering in a subsequent pressure filtration stage. The approach is promising and may, when technically proven, provide an economic alternative to other processes which require larger process inventories in the main reaction equipment due to longer residence times. Accuracy of process control would be of paramount importance but, if this is achieved, it could lead to significant economies in process equipment costs.

.4 Zimpro

Status

Laboratory studies have been successfully conducted based on Zimpro's extensive experience with the processing of sludges by wet oxidation. Due to years of design and operating experience with their wet oxidation reactors and tubular heat exchangers, Zimpro have grounds for confidence in expecting to achieve in commercial practice the results predicted by their laboratory studies. They also have good cost estimating data for their standard reactors and heat exchangers.

Wet Carbonization vs Wet Oxidation: Optimum Case

In their study Zimpro have investigated both wet oxidation and wet carbonization. Zimpro's report uses the term "Heat Treatment" in place of "Wet Carbonization", and concludes, on the basis of economic analyses, that 3% partial wet oxidation, rather than wet carbonization, represents the optimum case for thermal treatment of peat slurries.

A flow diagram of the optimum case is given in Figure 2.3-2.

.5 IGT Wet Carbonization Studies

IGT have constructed a Process Research Unit (PRU) and conducted studies in the wet carbonization of peat slurries. The PRU is designed to permit variations in major process parameters, sampling and analysis. The work done has provided valuable independent comparison with results obtained by other researchers. IGT's objective was to establish optimum process conditions for thermally treating peat slurries for mechanical dewatering and thermal drying in subsequent process steps. The end product was intended to be a peat fuel which would be a suitable feedstock for the IGT Peatgas reactor. The range of operating conditions for which the PRU was designed are as follows:

- Temperature:	175°C - 290°C (350°F - 550°F)
- Pressure:	1.3 mPa - 7.6 mPa (190 psia - 1100 psia)
- Mean Residence Time:	10 min - 40 min
- Slurry Throughput:	6 l/min (1.6 USGPM) at 5 WT% dry solids

IGT's PRU is a valuable tool for testing raw peat samples of differing origins in order to establish optimum thermal parameters for purposes of process and equipment design. In fact, to our knowledge, this is the only currently available unit in which such testing can be conducted.

A report on IGT's PRU studies is included in Part 3. A piping and instrumentation diagram of the PRU is given in Figure 326-2.

235 GENERAL REMARKS ON THERMAL TREATMENT OF PEAT SLURRIES

The following remarks highlight general aspects of thermal treatment of peat slurries.

Thermal Treatment with Excess Oxygen

Most investigators are agreed that, when wet oxidation is carried out in the presence of excess oxygen, a high (and uneconomic) proportion of the peat solids are solubilized. This reduces recoveries of peat solids and consequently the recovery of heating value in the product fuel. Zimpro, who investigated wet oxidation in the presence of excess oxygen, report that partial oxidation of peat using limited oxygen input resulted in good filtration characteristics without excessive loss of heating value.

Effect of Supernatant Recycle

Zimpro investigated the use of supernatant recycle (see flow diagram Figure 2.3-1) and reported encouraging reductions in solubilization and enhanced recoveries of peat solids and product heating value.

Thermal Treatment of Peats of Differing Origins

All investigators report that raw peats of differing origins and humification behave differently under thermal treatment. JP-Energy find that less humified peat, while generally giving a lower dry solids product yield, will give a higher yield of volatile organic matter in the reactor and also a higher methane production in the anaerobic waste water treatment unit. It is considered essential that process and equipment design for thermal treatment plants be resource specific.

Feedstock Maceration, Slurry Pre-heating and Residence Time

While the residence time for thermal treatment of peat slurry is associated with, and measured by, its duration in the reactor, the reactions involved commence with slurry pre-heating. It has been found that with macerated peat the speed of initial reaction is significantly higher. Since maceration affects pumpability and will be optimized on that basis, its effect upon thermal treatment process and equipment design could be quite significant.

Effluents

All thermal treatment processes discharge toxic liquid effluents which must be satisfactorily treated and rendered safe for return to bog areas, or possibly to surface and sub-surface streams. The cost of effluent treatment imposes a severe penalty on the economic viability of thermal treatment processes. However, the anaerobic stage of effluent treatment must be credited with the value of methane gas which it produces for use as an in-plant fuel. Since greater solubilization of feed solids during thermal treatment provides higher yields of methane in anaerobic digestion, it places a premium on plant optimization to improve energy and cost balancing.

Energy Generation From Total Wet Oxidation

ORF and Zimpro both reported on electric power generation directly from total wet oxidation of peat slurries in their reactors. ORF have also studied the generation of thermal energy in the form of steam and hot water by wet oxidation of peat slurries. While these subjects are of interest in the context of energy from peat studies, they are outside the scope of this report.

Comparison of Major Process Parameters

Table 2.3-3 contains a brief comparison of major process parameters and products of the JP-Energy, Koppelman, ORF-Wetox and Zimpro processes.

TABLE 2.3-3

Comparison of Dewatering Processes

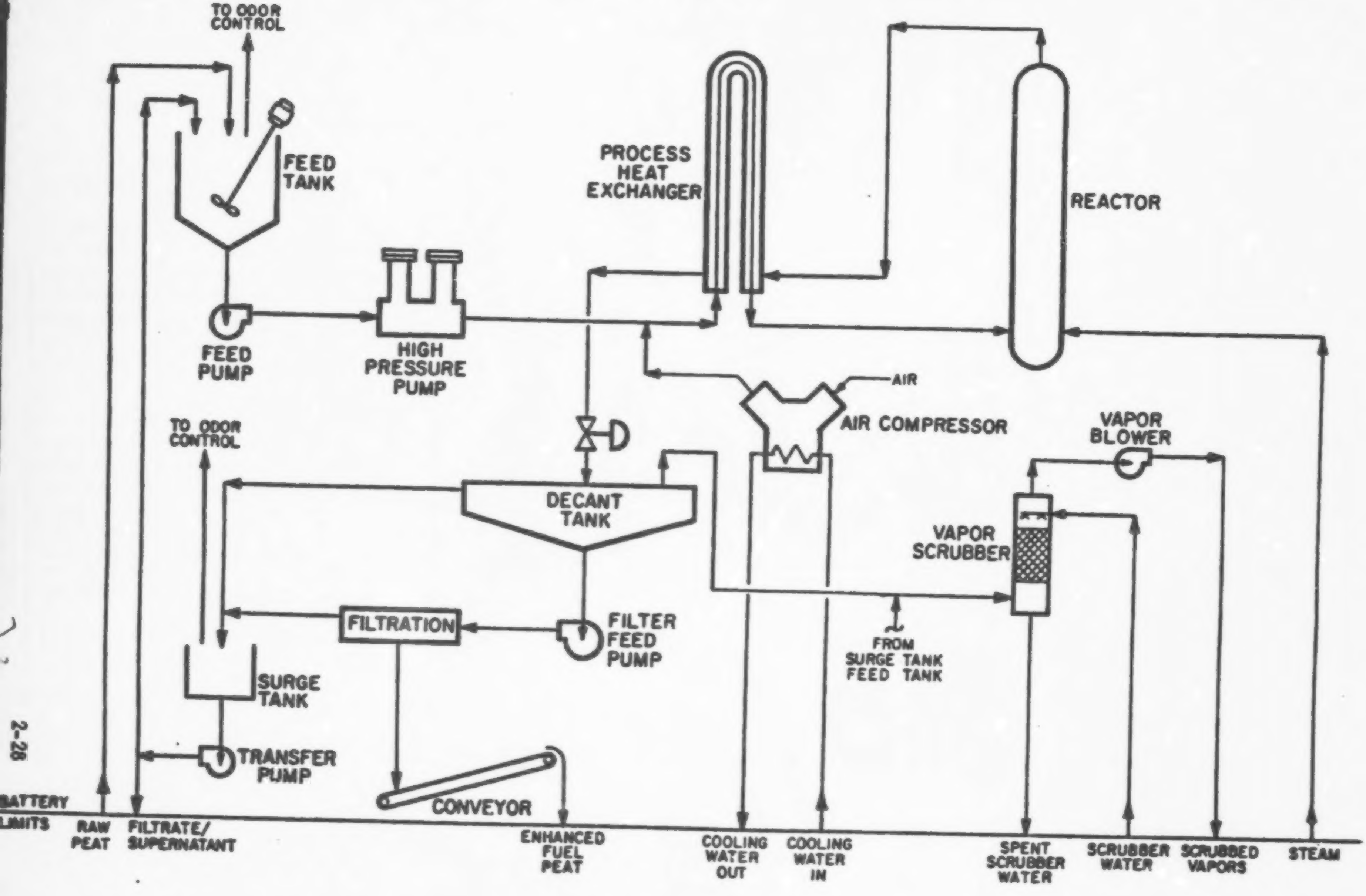
Process	Module Size (k.tonnes per year)	Reactor Conditions			Utility Consumptions (per kg of dry product)	Moisture Content (wt%)		Yields on Dry Basis, M=mass E=energy	Product HHV Dry Basis (MJ/kg)	Fuel Enhancement Product HHV / Feed HHV
		Temp (°C)	Press (kPa)	Time (minutes)		Filter Cake	Product			
JP-Energy Wet Carbonization	100-300	210	2500	30	Boiler feedwater 0.97 kg Power 0.163kWh Steam(generated in plant) 1.71 kg	50	10	M=60.0% E=72.7%	25.84	1.21
Koppelman K-Fuel	22-26	320	5515	15	Power 0.11 kWh Propane 0.034kg	N/A	5	M=74.0% E=90.2%	26.40	1.219
ORF Wet Air Oxidation (10.7% oxidation)	23-27	204	4580	10	Boiler feedwater 6.36 kg Power (incl. air) 0.45 kWh Air 1.68 kg Steam(generated in plant) 6.06 kg	50	33	M=61.6% E=66.5%	21.8	1.079
Zimpro Wet Air Oxidation (3% oxidation)	24-29	150	2170	30	Steam (imported) 0.57 kg Power (incl. air) 0.086kWh Air 0.33 kg	50	50	M=83.0% E=87.9%	20.39	1.022

Peat Slurry Feed Concentrations:

JP-Energy	9%	solids
Koppelman	50%	solids
ORF	10%	solids
Zimpro	7%	solids

LOW PRESSURE OXIDATION

FIGURE 2.3-1


TO ODOR CONTROL
FEED TANK
FEED PUMP
HIGH PRESSURE PUMP
PROCESS HEAT EXCHANGER
REACTOR
AIR
AIR COMPRESSOR
TO ODOR CONTROL
DECANT TANK
VAPOR BLOWER
VAPOR SCRUBBER
FILTRATION
FILTER FEED PUMP
FROM SURGE TANK FEED TANK
SURGE TANK
TRANSFER PUMP
CONVEYOR
BATTERY LIMITS
RAW PEAT
FILTRATE/ SUPERNATANT
ENHANCED FUEL PEAT
COOLING WATER OUT
COOLING WATER IN
SPENT SCRUBBER WATER
SCRUBBER WATER
SCRUBBED VAPORS
STEAM

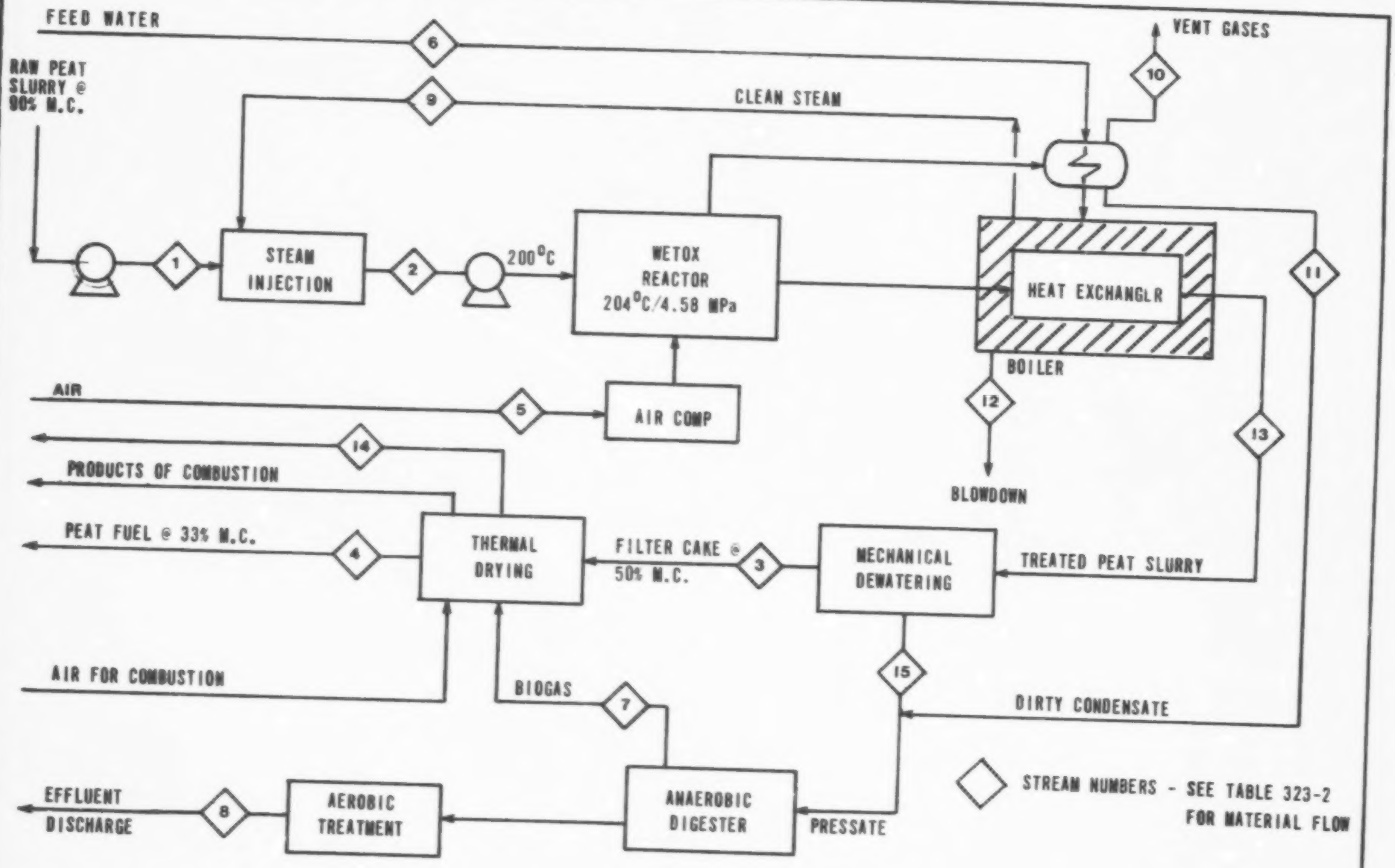
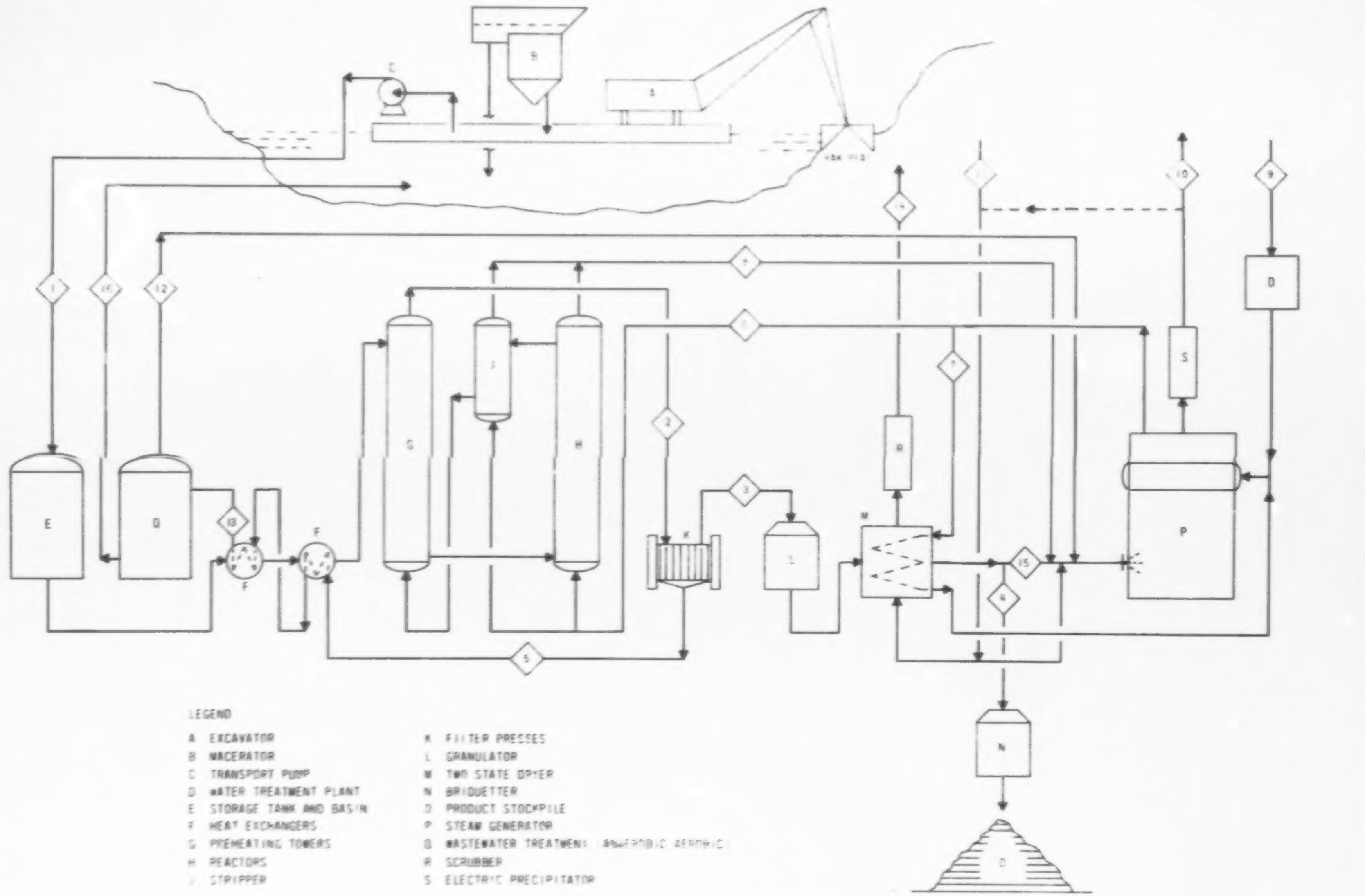
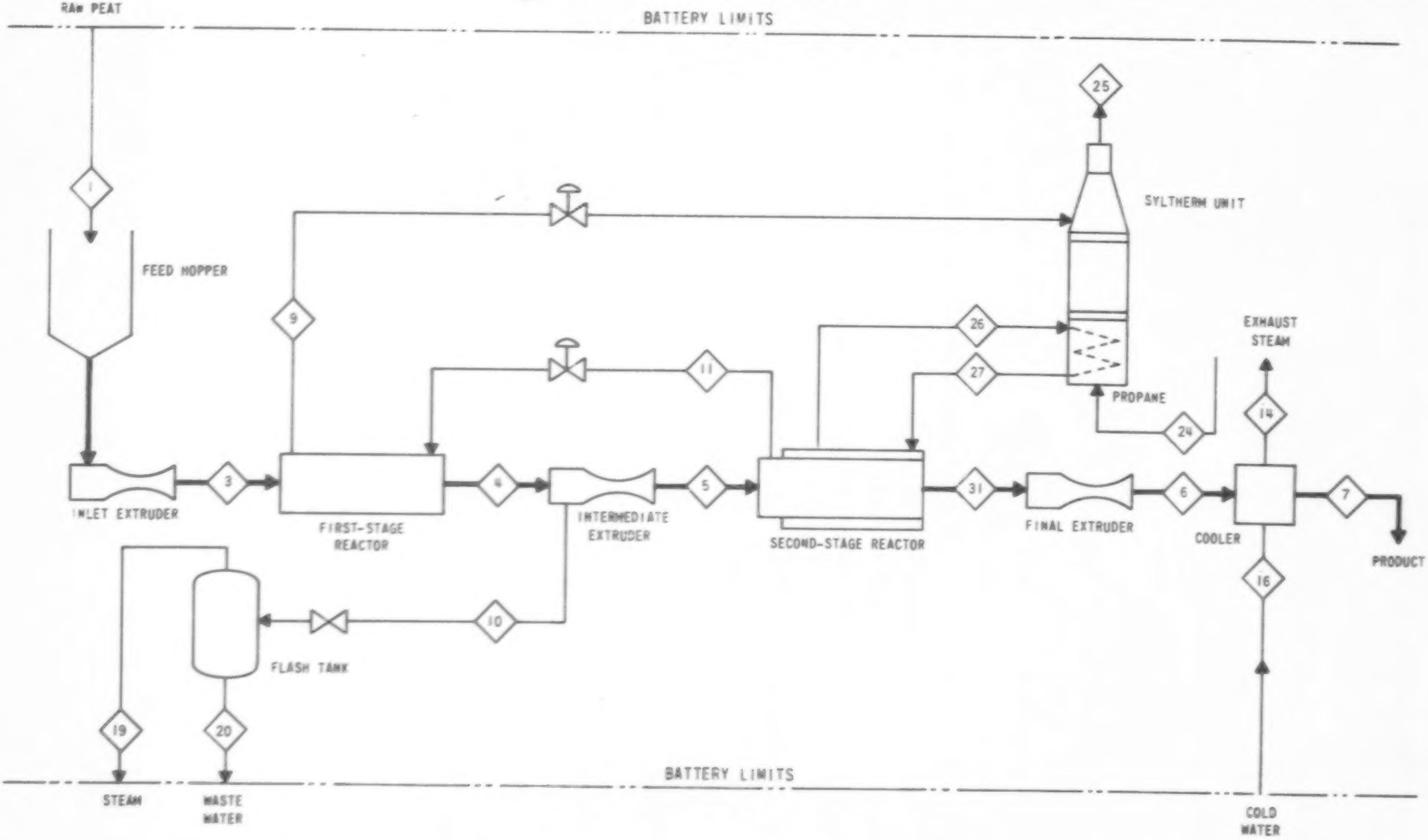

FEED WATER
RAW PEAT SLURRY @ 90% M.C.
6
9
CLEAN STEAM
VENT GASES
10
1
STEAM INJECTION
2
200°C
WETOX REACTOR 204°C/4.58 MPa
HEAT EXCHANGLR
BOILER
11
12
BLOWDOWN
AIR
5
AIR COMP
14
13
PRODUCTS OF COMBUSTION
PEAT FUEL @ 33% M.C.
4
THERMAL DRYING
FILTER CAKE @ 50% M.C.
3
MECHANICAL DEWATERING
TREATED PEAT SLURRY
AIR FOR COMBUSTION
BIOGAS
7
15
DIRTY CONDENSATE
EFFLUENT DISCHARGE
8
AEROBIC TREATMENT
ANAEROBIC DIGESTER
PRESSATE
STREAM NUMBERS - SEE TABLE 323-2 FOR MATERIAL FLOW

FIGURE 2.3-2

PARTIAL WET OXIDATION/
DEWATERING OF PEAT
ORF CASE 3


A
B
C
D
E
F
G
H
I
K
L
M
N
O
P
Q
R
S
1
2
3
4
5
7
9
10
12
13
14
15
16
LEGEND
A EXCAVATOR
B MACERATOR
C TRANSPORT PUMP
D WATER TREATMENT PLANT
E STORAGE TANK AND BASIN
F HEAT EXCHANGERS
G PREHEATING TOWERS
H REACTORS
I STRIPPER
K FILTER PRESSES
L GRANULATOR
M TWO STATE DRYER
N BRIQUETTER
O PRODUCT STOCKPILE
P STEAM GENERATOR
Q WASTEWATER TREATMENT (ANAEROBIC AEROBIC)
R SCRUBBER
S ELECTRIC PRECIPITATOR

JP-ENERGY PROCESS
FLOW DIAGRAM
300,000 TONNE/YR PLANT
FIGURE 2.3-3


RAW PEAT
BATTERY LIMITS
1
FEED HOPPER
INLET EXTRUDER
3
9
FIRST-STAGE REACTOR
4
INTERMEDIATE EXTRUDER
5
11
10
FLASH TANK
19
20
STEAM
WASTE WATER
SECOND-STAGE REACTOR
26
27
25
SYLTHERM UNIT
PROPANE
24
31
FINAL EXTRUDER
6
COOLER
EXHAUST STEAM
14
16
7
PRODUCT
BATTERY LIMITS
COLD WATER

FLOW DIAGRAM OF 25,000 TON/YR
K-FUEL PLANT IN NORTH CAROLINA
FIGURE 2 3-4

Approximate Mass and Energy Balances of Thermal Treatment Processes

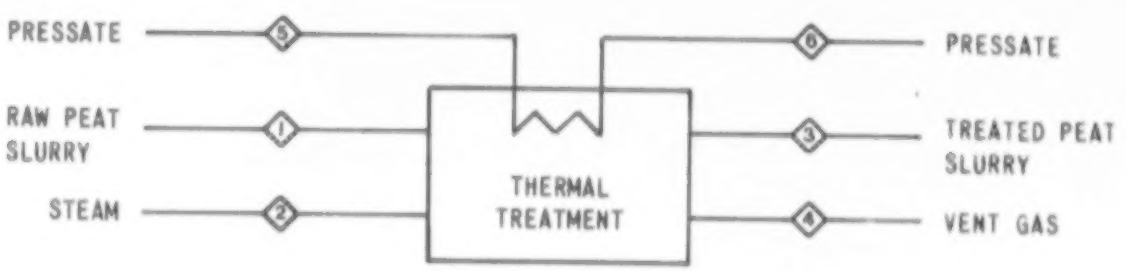
Rough trial balances drawn by Monenco, for JP-Energy, ORF-Wetox and Zimpro thermal treatment of peat slurries, are presented in Tables 2.3-4, 2.3-5, and 2.3-6. In attempting these balances, thermal treatment was isolated, as a unit process, from the rest of the process plant in each case. Since Monenco did not have access to all process design data, caution is advocated, for the figures obtained do not necessarily balance, and no accuracy is claimed for them. However, the directions indicated by the results were found sufficiently interesting to warrant including these approximations in the report. Despite imbalances, the figures enable a rough comparison of the processes with respect to the relation of input-output streams and of proportions between output streams. Thus, for example:

STREAM	COMPONENT	PERCENTAGE OF TOTAL		
		JP-ENERGY	ORF-WETOX	ZIMPRO
Treated Peat Slurry	Solids Water/Steam Dissolved Solids	6.84 91.89 1.27	5.84 93.12 1.04	6.04 93.41 0.55

It is interesting to speculate upon the relationships of such figures in the context of the comparison of major process parameters presented in Table 2.3-3. Any conclusions drawn from such reviews should, however, as advised above, be treated with the greatest caution. Those who are seriously interested in process details are advised to refer to their queries to the respective process licencors.

TABLE 2.3-4
TRIAL HEAT AND MASS BALANCE
JP-ENERGY THERMAL TREATMENT UNIT PROCESS

MASS FLOWS IN KG/HR - ENTHALPY IN GJ/HR

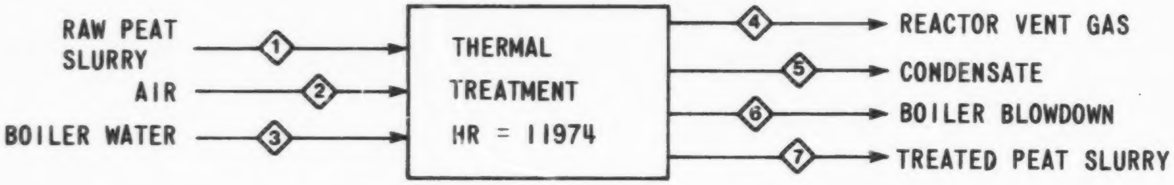

PRESSATE
⑤
⑥
PRESSATE
RAW PEAT SLURRY
①
③
TREATED PEAT SLURRY
THERMAL TREATMENT
STEAM
②
④
VENT GAS

	① RAW PEAT SLURRY	② STEAM
SOLIDS	60,000.0	-
WATER/STEAM	606,666.5	34,850.0
GAS	-	-
TOTAL	666,666.5	34,850.0
ENTHALPY (ABOVE 0°C)	45.204	97.474

	③ TREATED PEAT SLURRY	④ REACTOR VENT GAS	⑤ PRESSATE ⑥ PRESSATE
SOLIDS	47,274.0	977.5	8,359.5
WATER/STEAM	634,976.5	6,540.0	607,131.0
GAS	-	2,985.5	-
DISSOLVED SOLIDS	8,743.0	-	8,359.5
TOTAL	690,993.5	10,503.0	623,850.0
ENTHALPY (ABOVE 0°C)	222.222	19.015	⑤ 208.5 ⑥ 104.3

TABLE 2.3-5
TRIAL HEAT AND MASS BALANCE
WETOX THERMAL TREATMENT UNIT PROCESS

MASS FLOW IN KG/HR - ENTHALPY IN GJ/HR

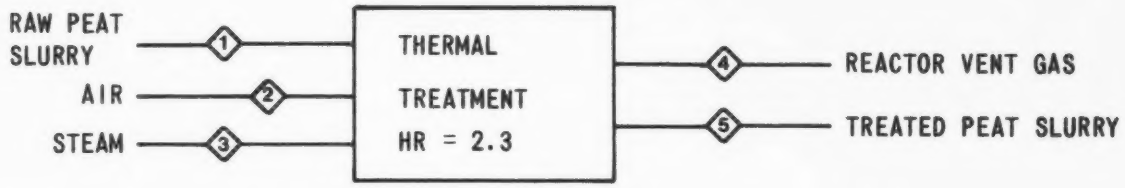

RAW PEAT SLURRY
AIR
BOILER WATER
①
②
③
THERMAL TREATMENT
HR = 11974
④
⑤
⑥
⑦
REACTOR VENT GAS
CONDENSATE
BOILER BLOWDOWN
TREATED PEAT SLURRY

	① RAW PEAT SLURRY	② PROCESS AIR	③ BOILER FEED WATER MAKE-UP	④ REACTOR VENT GASES
SOLIDS	5,357	0	0	0
WATER/STEAM	48,213	0	21,000	230.5
GAS	0	5,536	0	5,858.0
DISSOLVED SOLIDS	0	0	0	0
TOTAL	53,570	5,536	21,000	6,088.5
ENTHALPY (ABOVE 0^oC)	4.2445	0.2286	1.7611	0.8405

	⑤ REACTOR VENT GAS CONDENSATE	⑥ BOILER BLOW-DOWN	⑦ TREATED PEAT SLURRY	PRESSATE	FILTER CAKE
SOLIDS	0	0	4,060.6	760.6	3,300
WATER/STEAM	3,318.5	960	64,704	61,444	3,260
GAS	0	0	0	0	
DISSOLVED SOLIDS	0	0	723	683	40
TOTAL	3,318.5	960	69,487.6	62,887.6	6,600
ENTHALPY (ABOVE 0^oC)	1.7765	0.8242	14.7678		
ESTIMATED TEMP (^oC)			51		

TABLE 2.3-6
TRIAL HEAT AND MASS BALANCE
ZIMPRO THERMAL TREATMENT UNIT PROCESS

MASS FLOWS ARE IN KG/HR - ENTHALPY IN GJ/HR


RAW PEAT SLURRY
AIR
STEAM
①
②
③
THERMAL TREATMENT
HR = 2.3
④
⑤
REACTOR VENT GAS
TREATED PEAT SLURRY

	① RAW PEAT SLURRY	② PROCESS AIR	③ STEAM
SOLIDS	4,105	0	0
WATER/STEAM	54,532	0	1,963
GAS	0	1,118	0
TOTAL	58,637	1,118	1,963
ENTHALPY (ABOVE 0°C)	3.664	0.053	5.497

	④ REACTOR VENT GAS	⑤ TREATED PEAT SLURRY	PRESSATE
SOLIDS	0	3,647	240
WATER/STEAM	71	56,424	53,037
GAS	1,188	0	0
DISSOLVED SOLIDS	0	334	314
TOTAL	1,259	60,405	53,591
ENTHALPY (ABOVE 0° C)	0.236	10.856	
ESTIMATED TEMP (°C)		44	

236 COST OF THERMAL TREATMENT

Estimated costs of thermal treatment of peat slurries by the JP-Energy, ORF-Wetox and Zimpro processes are given in Tables 2.3-7, 2.3-8 and 2.3-9.

TABLE 2.3-7
COST OF JP-ENERGY
THERMAL TREATMENT OF PEAT SLURRY
1983 CDN DOLLARS

No.		Units	COST OF TREATMENT AT PLANT CAPACITY OF 25,000 Tonnes/yr	50,000 Tonnes/yr	100,000 Tonnes/yr	300,000 Tonnes/yr of PDF
1.	Capital Investment	$	0	0	0	54,500,000
2.	Annual Capital Charges	$/yr				8,707,000
3.	Annual O&M Costs	$/yr				3,843,000
	Fixed Annual Cost	$/yr				12,550,000
4.	Annual Variable Costs	$/yr				670,000
	Total Annual Costs	$/yr				13,220,000
5.	Cost of Product/Weight (300,000 x 0.9 = 270,000 T/yr dry basis) (X)	$/tonne				49.00
6.	Cost of Product/Energy (23.256 GJ/T x 300,000 T/yr = 6,976,800 GJ/yr.) (X)(Y)	$/GJ				1.90

Notes: (X) These are costs of thermal treatment of raw peat slurry excluding cost of feedstock.

In arriving at cost of product, adjustment is made to price the product on a dry basis: Peat Derived Fuel (PDF) is produced by the JP-Energy processes in the form of pellets or briquettes containing 10% moisture. Hence product in dry tonnes per year = 0.9 x 300,000 = 270,000 DTPY.

(Y) HHV of PDF @ 10% M.C. is taken from Table 2.3-3
25.84 x 0.9 = 23.256 GJ/T

Support for this analysis is given in Tables 321-11 and 321-12.

TABLE 2.3-8
COST OF WETOX THERMAL TREATMENT OF PEAT SLURRY
1983 CDN DOLLARS

No.		Units	COST OF TREATMENT AT PLANT CAPACITY OF 24,750 Tonnes/yr	50,000 Tonnes/yr	100,000 Tonnes/yr	300,000 Tonnes/yr
1.	Capital Investment	$	4,310,000	0	0	0
2.	Annual Capital Charges	$/yr	690,000			
3.	Annual O&M Costs	$/yr	960,000			
	Fixed Annual Cost	$/yr	1,650,000			
4.	Annual Variable Costs	$/yr	445,150			
	Total Annual Costs	$/yr	2,095,150			
5.	Cost of Processing/Weight (24,750 DTPY) (X)	$/tonne	84.65			
6.	Cost of Processing/Energy (21.8 GJ/T x 24,750 T/yr = 539,550 GJ/yr.) (X)	$/GJ	3.88			

Note: (X) - These are costs of thermal treatment of raw peat slurry excluding cost of feedstock.

- Support for this analysis is provided in Tables 323-14 to 323-17.

TABLE 2.3-9
COST OF ZIMPRO THERMAL TREATMENT OF PEAT SLURRY
1983 CDN DOLLARS

No.		Units	COST OF TREATMENT AT PLANT CAPACITY OF			
			25,550 Tonnes/yr	50,000 Tonnes/yr	100,000 Tonnes/yr	300,000 Tonnes/yr
1.	Capital Investment	$	6,362,400	0	0	0
2.	Annual Capital Charges	$/yr	1,016,500			
3.	Annual O&M Costs	$/yr	1,103,000			
	Fixed Annual Cost	$/yr	2,119,500			
4.	Annual Variable Costs	$/yr	235,000			
	Total Annual Costs	$/yr	2,354,500			
5.	Cost of Processing/Weight (25,550 DTPY) (X)	$/tonne	92.00			
6.	Cost of Processing/Energy (20.3553 GJ/T x 25,550 T/yr = 520,078 GJ/yr) (X)	$/GJ	4.50			

Note: (X) - These are costs of thermal treatment of raw peat slurry excluding cost of feedstock.

- Support for this analysis is given in Tables 324-20 to 324-23.

2.4 MECHANICAL DEWATERING SYSTEMS

Mechanical dewatering of peat has been attempted using a variety of machines which are classed mainly as pressure filters and centrifuges. A few manufacturers of such equipment are listed below:

Ingersoll-Rand - manufacture a twin roller "Vari-Nip" filter press, one of which is currently in operation at Fisons-Western Peat Moss operations in British Columbia. It is reported to give good results on moss peat. An incoming slurry containing about 6% dry solids is dewatered to about 30% dry solids.

Sulzer Brothers - manufacture a "Multi-Nip" belt press which they have tested on a variety of European and American peats with incoming slurry concentrations of 8.4% to 16% dry solids. They claim to have produced filter cakes containing 32.6% to 37.5% dry solids using humified fuel peats ranging from H2 to H10 on the von Post scale.

Sulzer also manufacture a hydrostatic press which they claim to have recently tested with raw peat slurries in combination with their belt presses, with remarkable results.

The Axel Johnson Group - make a Multibelt Press which has been undergoing trials with raw peat at a test site of the Swedish Peat Refining Co. (Svensk Torvforadling AB) at Grodinge, which is about an hour's drive south of Stockholm. The peat is fed to the press at about 10% dry solids and sustains a loss of about 0.4% dry solids in the filtrate.

Centre de Recherche Industriel du Quebec (CRIQ) - has developed a rotary dewatering press which takes in raw peat at 5% to 20%

dry solids and produces a filtered material containing 30% dry solids. It claims to operate with equal efficiency on horticultural and fuel peats and has to date been tested with local peats at St. Foy in Quebec, Canada.

Valmet-Vapo-International (VVI) - have recently developed a Water Suction (WS) Dryer which takes in a macerated peat slurry at about 5% to 7% dry solids and gives a product containing about 26% dry solids with almost no loss of fines. This WS dryer is used in combination with their patented thermal dryer to constitute a peat fuel plant (See Part 331).

Humbolt-Bird - Models S.1 and S.2 Decanter Centrifuges have been tested at the Royal Institute of Technology, Stockholm, Sweden, in a system for classifying a raw peat slurry into two streams. One stream containing the fines up to about 10 micron in size (90% < 10 micron), which constitutes between 10% and 20% of the dry solids in the feed leaves the upper end of the centrifuge along with 60% to 80% of the water. The second stream contains the balance of the water and all of the coarse particles (above 10 micron). The first stream is subjected to flocculation to recover the fines and the second stream to regular mechanical filtration to recover the coarse materials with little or no loss.

Experience with filtration of raw peat indicates that the less humified moss peat of von Post numbers 1 to 3 is more easily retained in the filter cake than the more humified fuel peat of von Post numbers 4 to 10. The more humified fuel peat, being more decomposed, has higher proportions of colloidal matter of less than 10 micron size. This colloidal matter passes through both the filter cake and the filter and is lost in the filtrate. This loss of fines constitutes a direct loss in fuel value of the product and should be held to a minimum.

While manufacturers have tested their machines with raw peat, they have not, to our knowledge, tested them with thermally treated peat. Although there is uniform concensus among researchers that thermally treated peat will dewater down to 50% moisture content, all dewatering of thermally treated peats appear to date to have been carried out in laboratory units. How closely these results will be confirmed by testing on commercial presses remains to be seen.

Sulzer claim to have made a significant breakthrough in the pressure filtration of raw peat. Information received from Peatco, shortly before the printing of this report, includes technical and cost information about a Sulzer peat dewatering plant consisting of one hydrostatic and two belt presses which, it is claimed, would dewater a peat slurry from 93% M.C. to 50% M.C. The information was cost analyzed and is included in Part 3 of the report, but there was not sufficient time to review the matter with Peatco or Sulzer.

From Tables 333.60-2.4 and 333.60-3.4 it is computed that mechanical dewatering of raw peat slurries from 93% to 70% M.C. in Larox filter presses would consume about 17 kJ of electrical energy per kg of water removed. From Table 333.10-7 it is computed that Sulzer would expect to dewater raw peat slurries in their dewatering plant while consuming about 30 kJ of electrical energy per kg of water removed.

Valmet-Vapo International of Finland have developed a unique water suction (WS) dryer which is under construction as a demonstration unit, and is expected to be in operation by end 1983. The WS dryer constitutes the first stage of the VVI peat drying system whose second process stage is a thermal dryer. Both are evaluated in Part 3 of this report.

Specific Costs

Specific costs of mechanical dewatering of peat slurries are present in Table 2.4-1. Economic analyses of Larox pressure filter modules from which the specific costs are derived are presented in Tables 2.4-2 and 2.4-3.

The estimated costs of mechanical dewatering in the ORF-Wetox and Zimpro processes are analyzed in Tables 2.4-4 and 2.4-5.

Specific Energy Consumptions

Specific energy consumptions of pressure filters appear to of the order of 17 kJ to 30 kJ per kilogram of water removed. Part 2.5 suggests qualifiers when comparing the specific energy consumptions of mechanical dewatering and thermal drying processes.

TABLE 2.4-1

Specific Costs of Mechanically Dewatering Peat Slurry

	Small Module C$	Large Module C$
Specific capital investment per dry tonne per year peat capacity	77.13	57.13
Specific capital investment per dry tonne per hour peat capacity	578,500	428,500
Specific annual cost of production per dry tonne per year peat capacity	34.00	17.60
Specific annual cost of production per dry tonne per hour peat capacity	255,000	139,944

NOTES:- The cost of production excludes the cost of feedstock.

- Slurry feedstock is assumed to have 7% solids.
- Filter cake product is assumed to have 50 wt.% moisture content if the feedstock is thermally treated peat slurry, and 70 wt % moisture content if the feedstock is raw peat slurry.
- Detailed economic analyses which compute these costs are provided in Tables 333.60-2 and 333.60-3.

TABLE 2.4-2
ECONOMIC ANALYSIS OF LAROX PRESSURE FILTER
SMALL MODULE, 4 T/H, USED IN 30,000 DTPY PLANT
COST OF PROCESSING
1983 CDN DOLLARS

		EX-PLANT COST OF PRODUCT AT PLANT CAPACITY OF		
No.		Units	37,500 D. Tonnes/yr	
1.	Capital Investment	$	2,314,000	
2.	Annual Capital Charges (CRF = 0.159761)	$/yr	370,000	
3.	Annual O&M Costs	$/yr	470,000	
	Fixed Annual Cost	$/yr	840,000	
4.	Annual Variable Costs	$/yr	180,000	(not including feedstock)
	Total Annual Costs	$/yr	1,020,000	
5.	Cost of Processing/Weight 30,000 DTPY	$/tonne	34.00	
6.	Cost of Processing/Energy 30,000 DTPY x 20 GJ/T = 600,000 GJ/YR.	$/GJ	1.70	

DERIVED SPECIFIC COSTS:

- Capital Investment: C$/DTPY = 2,314,000/30,000 = C$ 77.13/DTPY
  C$/DTPH = 2,314,000/4 = C$ 578,500/DTPH
- Annual Costs : C$/DTPY = 1,020,000/30,000 = C$ 34.00/DTPY
  C$/DTPH = 1,020,000/4 = C$ 255,000/DTPH

TABLE 2.4-3
ECONOMIC ANALYSIS OF LAROX PRESSURE FILTER
LARGE MODULE, 7.2 T/H, USED IN 270,000 DTPY PLANT
COST OF PROCESSING
1983 CDN DOLLARS

		EX-PLANT COST OF PRODUCT AT PLANT CAPACITY OF 270,000		
No.		Units	D. Tonnes/yr	
1.	Capital Investment	$	15,426,000	
2.	Annual Capital Charges (CRF = 0.159761)	$/yr	2,465,000	
3.	Annual O&M Costs	$/yr	935,000	
	Fixed Annual Cost	$/yr	3,400,000	
4.	Annual Variable Costs	$/yr	1,350,000	(not including feedstock)
	Total Annual Costs	$/yr	4,750,000	
5.	Cost of Processing/Weight 270,000 DTPY	$/tonne	17.59	
6.	Cost of Processing/Energy 270,000 DTPY x 20 GJ/T = 5,400,000 GJ/YR.	$/GJ	0.88	

DERIVED SPECIFIC COSTS:

- Capital Investment: C$/DTPY = 15,426,000/270,000 = C$ 57.13/DTPY
  C$/DTPH = 15,426,000/36 = C$ 428,500/DTPH
- Annual Costs : C$/DTPY = 4,750,000/270,000 = C$ 17.59/DTPY
  C$/DTPH = 4,750,000/36 = C$ 139,944/DTPH

TABLE 2.4-4
ESTIMATED COST OF MECHANICAL DEWATERING IN THE WETOX PLANT
1983 CDN DOLLARS

No.		Units	EX-PLANT COST OF PRODUCT AT PLANT CAPACITY OF 24,750 D.Tonnes/yr	50,000 Tonnes/yr	100,000 Tonnes/yr	300,000 Tonnes/yr
1.	Capital Investment	$	4,929,000	0	0	0
2.	Annual Capital Charges (CRF = 0.159761)	$/yr	787,000			
3.	Annual O&M Costs	$/yr	432,600			
	Fixed Annual Cost	$/yr	1,219,600			
4.	Annual Variable Costs	$/yr	195,000			
	Total Annual Costs	$/yr	1,414,600			
5.	Cost of Product/Weight	$/tonne	57.15			
6.	Cost of Product/Energy (21.8 GJ/DT x 24,750 DTPY = 539,550 GJ/yr)	$/GJ	2.62			

Notes:

1. Installed cost $3,087,000 is taken from Table 323-8 and Total Capital Investment $4,929,000 as above is developed by the standard procedure of this study.

3.&4. Annual O&M and Annual Variable costs are developed by our standard procedure, using data from Table 323-9.

TABLE 2.4-5
ESTIMATED COST OF MECHANICAL DEWATERING IN THE ZIMPRO PLANT
1983 CDN DOLLARS

			EX-PLANT COST OF PRODUCT AT PLANT CAPACITY OF			
No.		Units	25,550 D.Tonnes/yr	50,000 Tonnes/yr	100,000 Tonnes/yr	300,000 Tonnes/yr
1.	Capital Investment	$	10,704,000	0	0	0
2.	Annual Capital Charges (CRF = 0.159761)	$/yr	1,710,000			
3.	Annual O&M Costs	$/yr	759,000			
	Fixed Annual Cost	$/yr	2,469,000			
4.	Annual Variable Costs	$/yr	50,000			
	Total Annual Costs	$/yr	2,519,000			
5.	Cost of Product/Weight	$/tonne	98.59			
6.	Cost of Product/Energy (20.3553 GJ/T x 25,550 DTPY = 520,078 GJ/yr)	$/GJ	4.844			

Note: Data for this analysis is obtained from Table 324-14 and the "Cost Per Unit Process" breakdown presented on pages 3-179 to 3-181.

2.5 THERMAL DRYING SYSTEMS

Thermal drying is generally regarded as a more energy intensive system, per unit weight of water to be removed, than mechanical dewatering. It is therefore utilized in the final stages of peat dewatering, when other methods cannot further reduce the moisture content. If thermal drying follows mechanical dewatering of "raw" peat, it receives its feedstock at around 70% moisture content and delivers product at a moisture content depending on the desired end use. If thermal drying follows upon mechanical dewatering of "thermally treated" peat, it receives feedstock at 50% moisture content and delivers product at moisture contents as low as necessary consistent with end use requirement. Note: In the absence of data on the subject it is presently assumed that power consumption by filter presses would be the same in both cases. However, when data becomes available, this assumption must be closely reviewed.

Thermal dryers are technically well developed and commercially marketed equipment, supplied in standard and custom designs and ratings by numerous international manufacturers, including those listed below:

- Rotary Dryers:
    - o M-E-C Company, U.S.A.
    - o Heil Inc., U.S.A.
    - o Ahlstrom, Finland

- Flash Dryers:
    - o Ahlstrom, Finland
    - o Outokumpu, Finland

- Fluid Bed Dryers:
    - o Escher Wyss, Switzerland

- Multiple-Effect Evaporation: o Carver-Greenfield, U.S.A.

- Vapor-Compression/Absorption/
  Heat Pump Systems:
  - o Valmet-Vapo-International, Finland
  - o AIB, Sweden
  - o Uraken, Canada

Shortly before the printing of this report, Foster Wheeler Limited provided new information about a Carver-Greenfield process for dewatering peat slurries. There was not sufficient time to review the new development with the suppliers, but the data has been included in Part 3 of the report.

Valmet-Vapo International of Finland have developed a system for drying peat slurries in two stages. The first stage is a mechanical dryer and the second stage is a thermal dryer. Both are evaluated in Part 3 of this report.

Specific Energy Consumptions

In comparing specific energy consumptions of thermal dewatering processes with those of mechanical dewatering processes, a few points must be kept in mind:

- Adjustments must be made when comparing primary energy consumptions with electrical energy consumptions. Multiplying the latter by 5 would make the comparison more fair to the thermal processes.

- There is an economic penalty in higher plant capital charges and O&M costs when using primary energy.

- Mechanical drying is only applied to the earlier stages of drying very wet material, whereas thermal drying systems process relatively dry materials (below 50% M.C.) which are almost impossible to dry mechanically. As moisture content decreases, the specific energy consumption (in kJ/kg of water removed) increases, and so also the specific cost ($ per kg of water removed).

- Peat solids losses are higher (4% vs 1%) in mechanical than in thermal drying systems. These may either be accounted for directly in the economics or indirectly through the energy balances of the comparative systems.

The Carver-Greenfield process claims to be exceptionally energy efficient. Whereas flash and fluid bed driers have specific energy consumptions ranging from 3000 to 4000 kJ of primary energy per kg of water removed, the C-G process economics (presented in Table 334.42-4) claim 334 kJ per kg of water evaporation. However, the Carver-Greenfield process has not been commercially applied to dewatering peat, whereas flash and rotary dryers are in use at many commercial peat drying operations.

The specific energy consumption of JP-Energy's process for thermal drying of peat from 50% M.C. to 10% M.C. is computed as follows:

- Dry peat output	36 DTPH
- Water at 50% M.C.	36 TPH
- Water at 10% M.C.	4 TPH
- Water evaporated	32 TPH
- Steam consumption of dryer	97.58 GJ/hr
- Specific energy consumption	3,050 kJ/kg of water removed

The above data is taken from the process flow diagram (Figure 2.3-3) and the tabulation of Materials and Energy Flows (Table 321-1).

In their report ORF have assumed that a Heil Rotary Dryer would dry peat fuel from 50% to 30% moisture content consuming 3,800 kJ/kg of water removed.

The specific energy consumption of flash dryers which are cost analyzed in Tables 2.5-1 and 2.5-2 is 3,500 kJ/kg water removed (see Tables 334.50-5 and 334.50-8).

Specific Costs

Specific costs of thermally flash drying peat from 50% M.C. are given in Tables 2.5-1 and 2.5-2. The analysis is based on cost data kindly provided by Outokumpu of Finland.

Table 2.5-3 estimates the cost of thermal drying in the ORF-Wetox plant (drying from 50% to 30% M.C.).

Table 2.5-4 estimates the cost of thermal drying in a Carver-Greenfield peat drying plant (drying from 93% M.C. to dry).

The specific cost of thermal drying in the JP-Energy process (drying from 50% to 10% M.C.) is derived in the Economic Analysis, Part 2.7 of this report.

TABLE 2.5-1

Specific Costs of Thermally Flash Drying Fuel Peat from 50% to 10% M.C.

	Small Module 56,600 T/yr C$	Large Module 300,000 T/yr C$
Specific capital investment per tonne/yr (product) plant capacity	202.00	114.00
Specific capital investment per tonne/hr (product) plant capacity	1,517,000	855,000
Specific annual cost of drying per tonne/yr (product) plant capacity	47.00	24.00
Specific annual cost of drying per tonne/hr (product) plant capacity	353,500	183,000

NOTES: The cost of drying excludes the cost of feedstock and the loss of peat solids in the process.

Supporting information is provided in Table 2.5-2.

These figures are derived from general cost data kindly provided by Outokumpu of Finland.

TABLE 2.5-2
COST OF THERMALLY FLASH DRYING FUEL PEAT FROM 50% TO 10% M.C.
COST OF DRYING
1983 CDN DOLLARS

No.		Units	EX-PLANT COST OF DRYING AT PLANT CAPACITY OF Tonnes/yr	56,600 Tonnes/yr	100,000 Tonnes/yr	300,000 Tonnes/yr
1.	Capital Investment	$	0	11,452,000	0	34,190,000
2.	Annual Capital Charges	$/yr		1,830,000		5,462,000
3.	Annual O&M Costs	$/yr		838,000		1,864,000
	Fixed Annual Cost	$/yr		2,668,000		7,326,000
4.	Annual Variable Costs	$/yr		501,500		2,650,000
	Total Annual Costs	$/yr		3,169,500		9,976,000
5.	Cost of Drying/Weight (51,000/270,000 DTPY)	$/tonne		62.15		36.95
6.	Cost of Drying/Energy (1,020,000/5,400,000 GJ/yr)	$/GJ		3.10		1.85

NOTES:
- Cost of drying does not include cost of feedstock.
- Product M.C. is 10%.
- Supporting information for plant capacity of 56,600 TPY is in Tables 334.50-3 to 334.50-5.
- Supporting information for plant capcity of 300,000 TPY is in Tables 334.50-6 to 334.50-8.

TABLE 2.5-3
ESTIMATED COST OF THERMAL DRYING IN THE WETOX PLANT: 50% TO 30% M.C.
1983 CDN DOLLARS

			EX-PLANT COST OF PRODUCT AT PLANT CAPACITY OF			
No.		Units	24,750 DTonnes/yr	50,000 Tonnes/yr	100,000 Tonnes/yr	300,000 Tonnes/yr
1.	Capital Investment	$	687,550	0	0	0
2.	Annual Capital Charges (CRF = 0.159761)	$/yr	110,000			
3.	Annual O&M Costs	$/yr	289,000			
	Fixed Annual Cost	$/yr	399,000			
4.	Annual Variable Costs	$/yr	18,750			
	Total Annual Costs	$/yr	417,750			
5.	Cost of Product/Weight	$/tonne	16.88			
6.	Cost of Product/Energy (21.8 GJ/DT x 24,750 DTPY = 539,550 GJ/yr)	$/GJ	0.774			

Notes:

1. Installed cost $431,550 is taken from Table 323-8 and Total Capital Investment of $687,550 as above is developed using the standard procedure of this study.

3.&4. Annual O&M and Annual Variable Costs are developed by our standard procedure, using data from Table 323-9.

TABLE 2.5-4
CARVER-GREENFIELD PEAT DRYING SYSTEM 245,600 DTPY: 93% M.C. TO DRY
COST OF PRODUCT
1983 CDN DOLLARS

			EX-PLANT COST OF PRODUCT AT PLANT CAPACITY OF			
No.		Units	Tonnes/yr	Tonnes/yr	Tonnes/yr	245,600 Tonnes/yr
1.	Capital Investment	$	0	0	0	93,226,000
2.	Annual Capital Charges (CRF = 0.159761)	$/yr				14,894,000
3.	Annual O&M Costs	$/yr	________	________	________	4,018,000
	Fixed Annual Cost	$/yr				18,912,000
4.	Annual Variable Costs	$/yr	________	________	________	9,842,000
	Total Annual Costs	$/yr				28,754,000
5.	Cost of Product/Weight (245,600 DTPY Production)	$/tonne	________	________	________	117.08
6.	Cost of Product/Energy (245,600 DTPY x 20 GJ/T = 4,912,000 GJ/yr)	$/GJ				5.854

__NOTE__: Supporting data is provided in Tables 334.42-1 to 334.42-4.

2.6 EFFLUENT TREATMENT AND ENVIRONMENTAL CONSIDERATIONS

When wet-mined peat slurry has been dewatered by mechanical and thermal systems, the liquid effluent is considered to be chemically and biochemically unchanged. It is therefore regarded as environmentally acceptable to return such effluent without treatment to the bog and to use it in the wet-mining process.

When wet-mined peat slurry is thermally treated by wet carbonization or by wet oxidation prior to dewatering, then the effluent from the dewatering plant is considered potentially unsafe for discharge without treatment. It is expected that a two-stage anaerobic/aerobic digestion would render the effluent safe for discharge to the bog, and that methane generated in the first stage would be used as an in-plant fuel.

The quantity of effluent is generally 8 to 9.5 times the weight of the peat derived fuel. A 25,000 dry T/yr peat fuel plant would produce between 200,000 and 240,000 cubic meters of effluent per year, or 26 to 32 m^3/hr. This is about the smallest commercial size for a peat fuel plant. A medium size plant of 300,000 dry T/yr would annually discharge 2.7 million cubic meters at a rate of 360 cubic meters per hour (715 million USG/yr; 1,600 USGPM).

A U.S. study of a peat dewatering plant for a 250 million cubic feet per day SNG from peat facility investigated the technical and economic feasibility of producing 1,250 Tonnes per hour of 35 wt.% moisture content peat fuel for the gasifier (812.5 dry T/hr; 6,094,000 dry T/yr @ 7,500 Hrs/yr). Such a large peat dewatering plant would discharge about 7,700 m^3/hr (34,000 USGPM) of effluent.

JP-Energy, Zimpro and Koppelman expect effluents from peat fuel plants based on thermal treatment to have the characteristics shown in Table 2.6-1.

The cost of treatment to make the effluent safe for discharge back to the bog has been analyzed in Table 2.6-2 using data provided by Wheelabrator-Frye, the U.S. licencees of the JP-Energy process. The supporting data for Table 2.6-2 is available in Tables 321-13 to 321-16.

Table 2.6-3 estimates the cost of effluent treatment in the ORF-Wetox plant.

Peat dewatering and peat fuel plants are not expected to have any serious pollution potentials apart from those posed by effluents from thermal treatment processes. Combustion of peat in plant boilers poses known and well regulated hazards which, due to the low sulphur content of most peats, are generally lower than those arising from the combustion of coal.

TABLE 2.6-1

Expected Composition of Effluents from Thermal Treatment of Peat Slurry

QUALITY/CONSTITUENT	UNITS	JP-ENERGY	ZIMPRO	KOPPELMAN
- Temperature	°C	33.3		104
- Chemical Oxygen Demand (COD)	mg/l	21,000	9,400	24,550
- Biochemical Oxygen Demand (BOD_5)	mg/l	7,700	2,098	10,230
- Total Organic Carbon (TOC)	mg/l			51,150
- Ammonia Nitrogen (NH_3-N)	mg/l	515	65	66
- Total Solids (TS)	mg/l		6,900	
- Suspended Solids (TSS)	mg/l	1,400	500	
- pH	pH	4.4	3.8	4
- Phenols	mg/l		0.5	924
- Cyanide	mg/l			< 0.7
- Dissolved Organic Carbon (DOC)	mg/l		2,926	
- Total Kjeldahl Nitrogen (TKN)	mg/l	1,300	300	
- Phosphorus as P	mg/l		31.6	
- Phosphate	mg/l	31		
- Sulfate	mg/l	150		
- Sodium	mg/l	30		

TABLE 2.6-2
ESTIMATED COST OF TREATING WASTE WATER EFFLUENT FROM THE JP-ENERGY PROCESS
1983 CDN DOLLARS

No.		Units	COST OF TREATMENT AT PLANT CAPACITY OF 25,000 Tonnes/yr	 50,000 Tonnes/yr	 100,000 Tonnes/yr	 300,000 Tonnes/yr of PDF
1.	Capital Investment	$	0	0	0	14,921,000
2.	Annual Capital Charges (CRF = 0.159761)	$/yr				2,384,000
3.	Annual O&M Costs	$/yr				1,093,000
	Fixed Annual Cost	$/yr				3,477,000
4.	Annual Variable Costs	$/yr				705,000
	Total Annual Costs	$/yr				4,182,000
5.	Cost of Process/Prod. Weight (300,000 x 0.9 = 270,000 dry tonnes/yr)	$/tonne				15.49
6.	Cost of Process/Prod. Energy (23.256 GJ/T x 300,000 T/yr = 6,976,800 GJ/yr in product)	$/GJ				0.60

NOTE: As shown in Table 321-1, JP-Energy estimate that the heating value of methane generated in the anaerobic digestor would be 82.4 GJ/hr at this plant rating.

Supporting data for this analysis is given in Tables 321-13 to 321-16.

TABLE 2.6-3
ESTIMATED COST OF EFFLUENT TREATMENT IN THE WETOX PLANT
1983 CDN DOLLARS

			EX-PLANT COST OF PRODUCT AT PLANT CAPACITY OF			
No.		Units	24,750 DTonnes/yr	50,000 Tonnes/yr	100,000 Tonnes/yr	300,000 Tonnes/yr
1.	Capital Investment	$	3,618,000	0	0	0
2.	Annual Capital Charges (CRF = 0.159761)	$/yr	578,000			
3.	Annual O&M Costs	$/yr	322,000			
	Fixed Annual Cost	$/yr	900,000			
4.	Annual Variable Costs	$/yr	35,750			
	Total Annual Costs	$/yr	935,750			
5.	Cost of Product/Weight	$/tonne	37.80			
6.	Cost of Product/Energy (21.8 GJ/DT x 24,750 DTPY = 539,550 GJ/yr)	$/GJ	1.734			

Notes:

1. Installed cost of 2,268,000 is taken from Table 323-8 and Total Capital Investment $3,618,000 is developed by the standard procedure of this study.

3.&4. Annual O&M and Variable Costs are developed by standard procedure, using data from Table 323-9.

2.7 ECONOMIC ANALYSIS

271 TABULATION

This section tabulates, in Table 2.7-1, the specific costs of unit processes and combinations of unit processes in relation to Figure 2-1 and variations of Figure 2-1, such as those shown in Figures 2-2 and 2-3.

The tabulation is based on combinations of 3 variables:

- End product required:
  70%, 50%, 30%, 10% moisture content or dry peat fuel

- Feedstock available:
  Raw peat slurry - 6% to 10% solids
  Thermally treated peat slurry - 6% to 10% solids
  50% moisture content milled or similar peat feed

- Production capacities required:
  Ranging from 17,500 to 270,000 DTPY

Based on combinations of these three variables, unit processes or combinations of unit process are identified. Specific costs in $/tonne and $/GJ for each unit process are taken from economic analyses which have been presented in the report. Reference is given in the last column to tables from which the specific costs are taken or derived and to the related process flow diagrams or schematics, where applicable.

Significant Exclusions

In all cases specific costs represent only battery limits processing costs. The costs of feedstock and the costs of disposing of effluent are not included.

272 COMMENTARY

Table 2.7-1 is discussed briefly, by item, in the following commentary (please refer to the table as you read these comments):

ITEM	COMMENT
A, B, C, D	Raw peat slurry containing 7% solids can be dewatered to 70% M.C. (30% solids) in filter presses. Thermally treated slurry at the same solids concentration can be dewatered to 50% M.C. The specific costs are derived from cost data provided by Larox for one small (4.0 T/HR) module to produce 30,000 DTPY or five larger modules (7.0 T/HR) to produce 270,000 DTPY. Other filter presses, such as those listed in Figure 1-1, are also commercially marketed for similar use.
E, F	The Wetox and Zimpro wet air oxidation processes both thermally treat raw peat slurry in order to enhance dewatering. A comparison shows that, for the same level

of production (about 25,000 DTPY), their costs for thermal treatment compare very well indeed. Zimpro's marginally higher cost ($92.00/T vs. ORF's $84.65/T) may be accounted for by their extra cost for recycling supernatant in order to reduce solubilization of feed solids. ORF, on the other hand, state that feed solubilization quite possibly improves their plant total energy balance by increasing methane production from the downstream anaerobic treatment, thus providing an in-plant fuel source for the thermal drying process unit.

Since both studies were conducted independently, using entirely different proprietary processes, it is reassuring to find such a good cost comparison for the same level of annual production.

The cost of slurry storage at the plant is discussed in Part 2.2, and the specific costs are taken from Table 2.2-1.

Zimpro's and ORF's costs for mechanical dewatering differ substantially from each other and from those derived from Larox cost data as shown in Item C. For this reason, the two cost totals of Items E and F should be considered as requiring more detailed review.

NOTE: The cost of effluent treatment is not included in the cost totals of Items E and F. Since the slurry is thermally treated prior to dewatering,

ITEM	COMMENT
	effluent treatment would be essential. The reason for the exclusion is that Zimpro have not investigated the cost of effluent treatment in their report to DOE, and ORF, in their report to NRC, have estimated the cost only of anaerobic digestion. Since the purpose of Items E and F is to compare ORF and Zimpro process costs, inclusion of ORF's cost of effluent treatment would have distorted the comparison.
G	The VVI process has been very recently developed. The cost data supplied by VVI was entered in the standard format of the study and the specific cost was derived. A small demonstration plant, expected to be commissioned by end 1983 may confirm or modify this data. Should the data be confirmed, then the processing cost (at 17,500 DTPY) would compare favourably with that of the equivalent JP-Energy processing cost (at 270,000 DTPY) which is the Item I total, plus $15.49/T as the cost of effluent treatment, taken from Item M. However, such a conclusion would be premature at this stage, since the JP-Energy process is at a much more advanced stage of development, and its costing is accordingly more reliable.
H	As stated in Part 2.4, Peatco have, on behalf of Sulzer, provided technical and cost data about plant for mechanically dewatering raw peat slurries from 93% M.C. to 50% M.C., using a combination of hydrostatic and belt

ITEM	COMMENT

presses. The specific cost given in Table 2.7-1 is derived from the data provided by Peatco and analyzed in Part 3 of this report. However, there has been no opportunity to check this data. If confirmed, it would constitute a most important breakthrough in the mechanical dewatering of peat slurries.

I This Item is presented in order to discuss a comparison between the cost figures of Items D, E, F and I as follows:

Costs of Mechanical Dewatering (Items D : I : E&F)

The costs of mechanical dewatering of thermally treated peat slurries in Items D and I were derived quite independently of each other, using cost data from two distinct sources. Both were developed for production levels of 270,000 DTPY each and gave the following results:

- Item D from Larox data: $17.59/T
- Item I from JP-Energy data: $16.73/T

These costs compare so well that, if the results are not pure coincidence, the mechanical dewatering costs in Items A, B, C, D may be considered acceptable. On this premise, the mechanical dewatering costs in Items E and F, as developed from Zimpro and ORF data, raise questions and require more detailed review than this study can apply.

ITEM	COMMENT

Thermal Treatment Costs (E:F:I)

The costs of thermal treatment of raw peat slurries, as developed from data provided by Zimpro, ORF and JP-Energy, are as follows:

Annual Production Level DTPY	Process Name	Specific Costs $/Tonne	$/GJ
25,000	Zimpro	92.00	4.50
25,000	ORF-Wetox	84.65	3.88
270,000	JP-Energy	49.00	1.90

In the context of annual production levels the $/Tonne cost relationships appear reasonable. However, the $/GJ relationships are distorted by the claimed energy contents in the final product fuels.

J The first three elements of cost in this item have already been discussed above under Items E and F.

ORF's thermal drying process, using methane generated in the anaerobic digester is, in principle, similar to JP-Energy's thermal drying system, which uses steam generated partially by burning in-plant digester gas (See Item M). They compare as follows:

Annual Production Levels DTPY	Process Name	Drying Percentages % M.C.	Specific Costs $/Tonne	$/GJ
25,000	ORF-Wetox	50% to 30%	16.88	0.774
270,000	JP-Energy	50% to 10%	15.185	0.588

The apparent distortion in the last column, $/GJ, is attributable to the fact that JP-Energy claim greater enhancement of heating value by thermal treatment than do ORF. The more reliable comparison lies in the $/Tonne costs which, in the combined contexts of production levels and moisture content reductions, appear reasonable.

Both these specific costs are lower than the specific costs in Items K and L. This may be attributed to the benefit of using methane generated in the anaerobic stage as an in-plant fuel, thus improving plant energy balance.

ORF's costs of effluent treatment, when compared with those of JP-Energy in Item M, indicate a not unreasonable relationship in view of the difference in annual

ITEM	COMMENT
	production levels (25,000 vs 270,000 DTPY). However, while the data provided in ORF's report to NRC with regard to effluent treatment appeared to indicate that both anaerobic and aerobic treatments were included, the cost breakdowns given by ORF to Monenco showed only anaerobic digestion. The matter could not be clarified during the course of this study, but is probably quite simply explained.
K, L	Data received from Outokumpu, Finland, was analyzed in the standard format used for this study. For a production level of 270,000 DTPY the specific cost of thermal drying is 2.4 times that of JP-Energy. This is attributed to the benefits of optimized total energy balancing in the JP-Energy plant, which uses reactor gases and methane from anaerobic digestion as in-plant fuels as is shown in the referenced flow diagram in Figure 2.3-3.
M	The JP-Energy process is the most advanced process presently marketed for production of peat derived fuels from wet-mined peat. Review of their plant cost data, apportionment of plant costs to unit processes, and the comparisons made of JP-Energy unit process costs with unit process costs from other sources, indicate no discrepancies at this level of study. Comment on the various elements of specific cost in Item M has already been made in the discussion of earlier

ITEM	COMMENT
	items. The discussions, and the comparisons made, have served mainly to confirm the reasonableness of the JP-Energy cost data. The various elements of specific cost are derived by dividing the Total Annual cost in the last column of Table 321-12 by 270,000 DTPY and 6,976,800 GJ/yr, which are respectively the total annual weight of dry product and the total annual energy in product.
N	At the present time, the Koppelman process is expected to produce a high grade fuel from 50% M.C. peat. Future plans include using slurried peat feedstocks, but no performance or cost data has been provided in regard to those plant designs. Since the cost data provided for our analysis is claimed to be based upon a demonstration plant of about 25,000 DTPY already under fabrication, and fully contracted, we consider that this plant cost data is reliable. This data was produced by Koppelman in the format of our standard analysis and is so reproduced in Part 3 of the report. In the context of the differences between annual production levels and the feedstock moisture contents, the cost relationship between the fuels produced by JP-Energy process and the Koppelman process appears reasonable and acceptable. It will, however, be noticed that no provision has been made in the cost of K-Fuel for effluent treatment. An approximate order of cost may be derived using data presented in this report as follows (assuming that the

quality of effluent from all thermal processes is the same which, while not strictly accurate, is an acceptable simplification for the purpose in view):

Name	Fuel Production Rating Dry Basis DTPH	Quantity of Effluent to be Treated TPH	Cost of Effluent Treatment			Reference Table/ Figure
			C$/DT of Product	C$/Hr	C$/Tonne of Effluent	
JP-Energy	36	624	15.49	557.64	0.894	Figure 2.3-3 Table 321-1 Table 2.7-1
ORF-Wetox	3.3	66.46	37.80	124.74	1.878	Figure 2.3-2 Table 323-2 Table 2.7-1
Koppelman	2.853	3.56	(Z)	(Y)	(X)	Figure 2.3-4 Table 322-5

Assuming (X) = C$ 1.878/T. Eff. (the higher figure since the fuel production rating is similar)

Then (Y) = 1.878 x 3.56 = C$ 6.69/Hr

And (Z) = 6.69 ÷ 2.853 = C$ 2.34 per tonne of dry fuel product.

ITEM	COMMENT
	Such an additional amount would not significantly affect the cost relationships discussed.
O	This specific cost relates to the larger improved model, which is on the design board. The cost data for this larger module may not be as accurate as that for Item N, where the plant is costed on a fabrication basis.
P	Foster Wheeler Limited/Carver-Greenfield, U.S.A., have modified their regular multiple flash evaporation system to make it suitable for dewatering 93% M.C. raw peat slurries to produce an almost zero moisture content dry peat fuel. Cost data provided by FWL/C-G was analyzed and the results are very heartening, because this process appears to present no pollution hazard as there is no effluent return to the bog. Testing of peat samples can be carried out in one of two small process test units. The specific cost needs confirmation but, if found correct, would make the process a serious contender for producing dry peat fuels from wet-mined peat.

TABLE 2.7-1

ANALYSIS OF SPECIFIC COSTS OF PROCESSING RAW AND THERMALLY TREATED PEAT TO PRODUCE PEAT FUELS
(Feedstock Costs and Costs of Effluent Return to Bog are Excluded)

ITEM	PRODUCT FUEL MOISTURE CONTENT %	FEEDSTOCK	PRODUCTION CAPACITY IN DRY TONNES PER YEAR	SELECTED UNIT PROCESS COMBINATION	SOURCE OF DATA FOR THE COMPUTED SPECIFIC COST	SPECIFIC COST ON DRY BASIS		REFERENCE TABLES AND FIGURES FOR SUPPORTING INFORMATION
						$/TONNE	$/GJ	
A	70%	Macerated 7% Slurry Using Cleaned Raw Peat	30,000	- Mechanical Dewatering of Raw Peat Slurry (from 93% - 70% M.C.)	- Larox Filter Presses	- 34.000	- 1.700	Table 333.60-2.1
						34.000	1.700	
B	70%	Macerated 7% Slurry Using Cleaned Raw Peat	270,000	- Mechanical Dewatering of Raw Peat Slurry (from 93% - 70% M.C.)	- Larox Filter Presses	- 17.590	- 0.880	Table 333.60-3.1
						17.590	0.880	
C	50%	Thermally Treated 7% Slurry	30,000	- Mechanical Dewatering of Slurry Produced by Thermal Treatment Plant (from 93% to 50% M.C.)	- Larox Filter Presses	- 34.000	- 1.700	Table 333.60-2.1
						34.000	1.700	
D	50%	Thermally Treated 7% Slurry	270,000	- Mechanical Dewatering of Slurry Produced by Thermal Treatment Plant (from 93% to 50% M.C.)	- Larox Filter Presses	- 17.590	- 0.880	Table 333.60-3.1
						17.590	0.880	

TABLE 2.7-1 (Cont'd)

ANALYSIS OF SPECIFIC COSTS OF PROCESSING RAW AND THERMALLY TREATED PEAT TO PRODUCE PEAT FUELS
(Feedstock Costs and Costs of Effluent Return to Bog are Excluded)

ITEM	PRODUCT FUEL MOISTURE CONTENT %	FEEDSTOCK	PRODUCTION CAPACITY IN DRY TONNES PER YEAR	SELECTED UNIT PROCESS COMBINATION	SOURCE OF DATA FOR THE COMPUTED SPECIFIC COST	SPECIFIC COST ON DRY BASIS		REFERENCE TABLES AND FIGURES FOR SUPPORTING INFORMATION
						$/TONNE	$/GJ	
E	50%	Macerated 7% Slurry Using Cleaned Raw Peat	25,550	- Slurry Storage at Plant	- Monenco	- 2.624	- 0.130	Figure 2-1 Table 2.2-1
				- Thermal Treatment of Raw 7% Slurry	- Zimpro: Study for DOE 1982	- 92.000	- 4.500	Figure 2.3-1 Table 2.3-6
				- Mechanical Dewatering of Thermally Treated Slurry to 50% M.C.	- Zimpro: Study for DOE 1982	- 98.590	- 4.844	Figure 2.3-1 Table 2.4-5
						193.214	9.474	
F	50%	Macerated 10% Slurry Using Cleaned Raw Peat	24,750	- Slurry Storage at Plant	- Monenco	- 2.624	- 0.130	Figure 2-1 Table 2.2-1
				- Thermal Treatment of Raw 10% Slurry	- ORF: Study for NRCC 1982	- 84.650	- 3.880	Figure 2.3-2 Table 2.3-5
				- Mechanical Dewatering	- ORF: Study for NRCC	- 57.150	- 2.620	Figure 2.3-2 Table 2.4-4
						144.424	6.630	
G	50%	Macerated 7% Slurry Using Cleaned Raw Peat	17,500	- Slurry Storage at Plant	- Monenco	- 2.624	- 0.130	Figure 2-1 Table 2.2-1
				- Mechanical Dewatering (Stage I) and Thermal Drying (Stage II) in VVI-Peat Drying System (from 93% - 50% M.C.)	- Valmet-Vapo International	- 74.286	- 3.714	Figures 331-2/3/4 Table 331-1: after deducting feedstock cost from Item 4.
						76.910	3.844	

TABLE 2.7-1 (Cont'd)

ANALYSIS OF SPECIFIC COSTS OF PROCESSING RAW AND THERMALLY TREATED PEAT TO PRODUCE PEAT FUELS
(Feedstock Costs and Costs of Effluent Return to Bog are Excluded)

ITEM	PRODUCT FUEL MOISTURE CONTENT %	FEEDSTOCK	PRODUCTION CAPACITY IN DRY TONNES PER YEAR	SELECTED UNIT PROCESS COMBINATION	SOURCE OF DATA FOR THE COMPUTED SPECIFIC COST	SPECIFIC COST ON DRY BASIS		REFERENCE TABLES AND FIGURES FOR SUPPORTING INFORMATION
						$/TONNE	$/GJ	
H	50%	Macerated 7% Slurry Using Cleaned Raw Peat	39,375	- Slurry Storage at Plant	- Monenco	- 2.624	- 0.130	Figure 2-1 Table 2.2-1
				- Mechanical Dewatering of Raw Peat Slurry (from 93% to 50% M.C)	- Peatco, Canada for Sulzer Switzerland	- 61.500	- 3.080	Table 333.10-4 Figure 333.10-1
						64.124	3.210	
I	50%	Macerated 9% Slurry Using Cleaned Raw Peat	270,000	- Slurry Storage at Plant	- Monenco	- 1.275	- 0.064	Figure 2-1 Table 2.2-1
				- Thermal Treatment of 9% Raw Slurry	- JP-Energy Process Data from Wheelabrator-Frye U.S.A.	- 49.000	- 1.900	Figure 2.3-3 Table 2.3-4
				- Mechanical Dewatering of 7% Thermally Treated Slurry (from 93% to 50% M.C.)	- JP-Energy Process Data from Wheelabrator-Frye U.S.A.	- 16.730	- 0.647	Figure 2.3-3 Table 321-12
						67.005	2.611	
J	30%	Macerated 10% Slurry Using Cleaned Raw Peat	24,750	- Slurry Storage at Plant	- Monenco	- 2.624	- 0.130	Figure 2-1 Table 2.2-1
				- Thermal Treatment of 10% Raw Slurry	- ORF: Study for NRCC 1982	- 84.650	- 3.880	Figure 2.3-2 Table 2.3-5

TABLE 2.7-1 (Cont'd)

ANALYSIS OF SPECIFIC COSTS OF PROCESSING RAW AND THERMALLY TREATED PEAT TO PRODUCE PEAT FUELS
(Feedstock Costs and Costs of Effluent Return to Bog are Excluded)

ITEM	PRODUCT FUEL MOISTURE CONTENT %	FEEDSTOCK	PRODUCTION CAPACITY IN DRY TONNES PER YEAR	SELECTED UNIT PROCESS COMBINATION	SOURCE OF DATA FOR THE COMPUTED SPECIFIC COST	SPECIFIC COST ON DRY BASIS		REFERENCE TABLES AND FIGURES FOR SUPPORTING INFORMATION
						$/TONNE	$/GJ	
				- Mechanical Dewatering of Thermally Treated Slurry (from 94% to 50% M.C.) - Thermal Drying Using Methane Generated in Anaerobic Digester (from 50% to 30% M.C) - Effluent Treatment in Anaerobic Digestor	- ORF: Study for NRCC 1982 - ORF: Study for NRCC 1982 - ORF: Study for NRCC 1982	- 57.150 - 16.880 - 37.800	- 2.620 - 0.774 - 1.734	Figure 2.3-2 Table 2.4-4 Figure 2.3-2 Table 2.5-3 Figure 2.3-2 Table 2.6-3
						199.104	9.138	
K	10%	50% M.C. Milled Peat	51,000	- Thermal Flash Drying (from 50% to 10% M.C)	- Outokumpu, Finland	- 62.150	- 3.100	Table 2.5-2 Figure 334.10-1
						62.150	3.100	
L	10%	50% M.C. Milled Peat	270,000	- Thermal Flash Drying (from 50% to 10% M.C)	- Outokumpu, Finland	- 36.950	- 1.850	Table 2.5-2 Figure 334.10-1
						36.950	1.850	
M	10%	Macerated 9% Slurry Using Cleaned Raw Peat	270,000	- Slurry Storage at Plant - Thermal Treatment of 9% Raw Slurry	- Monenco - JP-Energy Process Data from Wheelabrator-Frye U.S.A.	- 1.275 - 49.000	- 0.064 - 1.900	Figure 2-1 Table 2.2-1 Figure 2.3-3 Table 2.3-4

TABLE 2.7-1 (Cont'd)

ANALYSIS OF SPECIFIC COSTS OF PROCESSING RAW AND THERMALLY TREATED PEAT TO PRODUCE PEAT FUELS
(Feedstock Costs and Costs of Effluent Return to Bog are Excluded)

ITEM	PRODUCT FUEL MOISTURE CONTENT %	FEEDSTOCK	PRODUCTION CAPACITY IN DRY TONNES PER YEAR	SELECTED UNIT PROCESS COMBINATION	SOURCE OF DATA FOR THE COMPUTED SPECIFIC COST	SPECIFIC COST ON DRY BASIS		REFERENCE TABLES AND FIGURES FOR SUPPORTING INFORMATION
						$/TONNE	$/GJ	
				- Mechanical Dewatering of 7% Thermally Treated Slurry (from 93% - 50% M.C.)	- JP-Energy Process Data from Wheelabrator-Frye U.S.A.	- 16.730	- 0.647	Figure 2.3-3 Table 321-12
				- Thermal Drying (from 50% to 10% M.C.)	- JP-Energy Process Data from Wheelabrator-Frye U.S.A.	- 15.185	- 0.588	Figure 2.3-3 Table 321-12
				- Effluent Treatment Anaerobic/Aerobic Digestion (evolving methane for in-plant use)	- JP-Energy Process Data from Wheelabrator-Frye U.S.A.	- 15.490	- 0.600	Figure 2.3-3 Table 2.6-2 Table 321-12
						97.670	3.799	
N	5%	50% M.C. Fuel Peat (Similar to Milled Peat)	21,400	- K-Fuel Process	- Edward Koppelman	- 105.760	- 4.014	Figure 2.3-4 Table 322-10: after deducting feedstock cost from Item 4.
						105.760	4.014	

TABLE 2.7-1 (Cont'd)

ANALYSIS OF SPECIFIC COSTS OF PROCESSING RAW AND THERMALLY TREATED PEAT TO PRODUCE PEAT FUELS
(Feedstock Costs and Costs of Effluent Return to Bog are Excluded)

ITEM	PRODUCT FUEL MOISTURE CONTENT %	FEEDSTOCK	PRODUCTION CAPACITY IN DRY TONNES PER YEAR	SELECTED UNIT PROCESS COMBINATION	SOURCE OF DATA FOR THE COMPUTED SPECIFIC COST	SPECIFIC COST ON DRY BASIS		REFERENCE TABLES AND FIGURES FOR SUPPORTING INFORMATION
						$/TONNE	$/GJ	
O	5%	50% M.C. Fuel Peat (Similar to Milled Peat)	42,800	- K-Fuel Process	- Edward Koppelman	- 65.310	- 2.478	Figure 2.3-4 Table 322-14: after deducting feedstock cost from Item 4.
						65.310	2.478	
P	DRY	Macerated 6% Slurry Using Cleaned Raw Peat	245,600	- Slurry Storage at Plant - Multiple Effect Evaporation by Steam & Vapor Compression Systems (from 94% Raw Slurry to 0.5% M.C. - dry fuel)	- Monenco - Carver-Greenfield Foster Wheeler	- 1.275 - 117.080	- 0.064 - 5.854	Figure 2-1 Table 2.2-1 Figure 334.42-2 Table 2.5-4
						118.355	5.918	

2.8 FEEDSTOCK REQUIREMENTS AND COSTS

281 WET-MINED PEAT

"Wet-mined" peat is the feedstock expected to be used by the dewatering processes which have been studied for this report. Wet-mined peat is described as in-situ peat transported from bog to dewatering plant without being dried at the bog. This, however, is a general description of peat feedstock for dewatering plants rather than a specification, since it embraces a number of variables. These variables take the forms tabulated in Table 2.8-1:

TABLE 2.8-1

VARIABLES IN WET-MINED PEAT FEEDSTOCKS

Variable	Variation	Remarks
1. Moisture Content of in-situ peat (wt.%)	o 85% - 95%	Typical range for Canadian, Northern U.S., Finnish, Irish, USSR bogs
	o 70% - 85%	Raised bogs in Southern and tropical regions.
	o 50% - 70%	Drained bogs in Southern and tropical regions.
2. Percent weight dry solids in peat for optimum slurry pumpability and storage characteristics	Slurry dry solids content 1% to 10% by weight.	There is considerable debate as to what constitutes a pumpable peat slurry.
	o 0.75% to 1.5% dry solids in peat slurry	Fisons-Western Peat in British Columbia, Canada. Existing operation.
	o 2-3% dry solids in peat slurry	Considered pumpable by Dravo/GRI
	o 3.5% dry solids	Considered max. for moss peat slurry (R. Vanasse).
	o 7% macerated dry solids in peat slurry	Considered pumpable by VVI.
	o 9% macerated dry solids in peat slurry	Considered pumpable by JP-Energy and Wheelabrator-Frye.
	o 10% dry solids (But 25% extra water entrained due to slurry pond dredging process)	Considered pumpable when dredged by Proehl Cutterhead (G.B. Morris).

TABLE 2.8-1 (Cont'd)

Variable	Variation	Remarks
3. Woody content, stumps, roots, logs, lumps, stones, gravel sand, tramp materials. Tough stringy fibrous wood and roots are particularly difficult inclusions.	Wide variation depending on individual bog location, formation and climatology.	All processors consider such materials reduce productivity at bog and require suitable equipment design. But the K-Fuel process prefers high wood content.

282 WET-MINED PEAT SLURRIES - BOUND AND FREE MOISTURE

When discussing the slurrying of peat it should be recognized that peat slurries suffer from an inherent problem of bonded moisture content. The bound moisture should be considered as a transported material rather than a part of the transport medium. Table 2.3-1 indicates that on average, 100 kg in-situ peat at 90% moisture content contains 90 kg of water. Of this 90 kg, only from 20 kg up to a maximum of 30 kg, is free water. The rest of the water is bound in micropores either colloidally or chemically, and is by no means free to reduce slurry viscosity by acting as a medium of transport. Hence 90% moisture content in-situ peat may as well be considered a 20% moisture content (80% solids) slurry. As anyone who has walked on a bog and scooped up peat with his hands knows, 90% moisture in-situ peat is not a material which flows by itself.

G.B. Morris states that a Proehl Cutter Head macerates the peat as it cuts into the bank and, by virtue of this being done partially under the level of the slurry pond water, 25% extra water is entrained in the dredge suction. This makes for a pumpable slurry and indicates that, in the process of suction dredging, 25 kg of free water would be added to every 100 kg of the in-situ peat, thus improving pumpability.

Dravo/GRI consider 3% dry solids is a maximum peat slurry concentration for pumpability of fuel peat while R. Vanasse considers 3.5% dry solids is a maximum concentration of dry solids for moss peat slurry pumping.

The systems suggested by Morris and Dravo do not have empirical support, and both cases require considerable work to be done to develop these concepts to an engineering level. It is therefore suggested that any development of peat slurrying systems should take account of bound versus free moisture associated with raw peat. The results obtained by Vanasse et al are based on data gathered from a test loop and are supportable, within the frame-work of their program, for moss peat. It would be interesting, and possibly not too expensive, to conduct similar tests on various mixes of H1-H10 peats.

Before closing reference to Vanasse's work it should be noted that Vanasse actually ground the moss peat to an average particle size of 0.7 mm and that the length to diameter ratio of the resulting fibers was of the order of 4. It is debatable if the Proehl Cutter-Head, with its heavy, widely spaced blades, could actually "macerate" peat as is claimed by Morris.

283 MACERATED PEAT SLURRIES

Both VVI and JP-Energy claim that macerating the peat at the bog allows the resulting slurry to be pumped at 7% (VVI) to 9% (JP-Energy) dry solids. We are advised this is based upon results obtained from a test loop which was set up and operated in Sweden. The results of this testing and the equipment used is considered confidential at this time by JP-Energy. The only information available from them about slurry preparation is: "The raw peat is screened and macerated at the extraction site to a pumpable slurry in pulpers. Coarse material and frozen lumps of peat must be crushed. This will be done by pontoon-mounted machinery at the bog. If the raw peat contains a large amount of wood that could affect pulping or if the peat occurs partly in a frozen state, the peat is crushed by a disc crusher prior to pulping".

VVI state: "The peat is extracted from the peat bog and processed through a disc grinder. The final product is a slurry which has liquid like characteristics. It is easy to pump and will not sedimentate even after long storage life." (presumably in a slurry basin). Also: "The task of grinding is most important in the VVI-technics. When extracted peat passes through the narrow spits of the grinder, the fibre-like peat body breaks down and makes peat easy to pump." (presumably this process frees considerable quantities of 'bound' water, which then changes from a transported constituent to a medium of transport). "After grinding when the dry content of the peat sludge is about 5% the kinematic viscosity of the peat is 80 times higher than that of pure water." Also "To keep the grinding energy cost low, it is especially important that the peat sludge is processed through the grinder with sufficient pressure in order to make the grinding time as short as possible. Excessive grinding time wastes energy." The diagram in Figure 2.8-1 shows the VVI wet-mining, pretreatment and slurry pumping system.

During their visit to Finland the study team were shown test-tube samples of macerated peat slurry (9% dry solids) by JP-Energy. It looked like a flowing, quite pumpable liquid and the solids did not settle out.

If the answer to the peat slurry problem is maceration at the bog, it should be possible to design a single multi-component unit which could accept peat excavated with a backhoe, clamshell or drag. This unit would be capable of screening, lump-and-wood crushing, removing tramp material, and feeding the cleaned, sized, peat to a grinder. The grinder would macerate the peat, with additional water if necessary, and produce a pumpable slurry to feed through the pump and slurry pipeline to a storage basin at the plant. Such a multi-component unit could be designed to be either barge-mounted or mobile so as to operate with excavators such as backhoes and clamshells or work with high pressure water monitors. Thus, depending upon the characteristics of the peat, the bog, sizes of roots, stumps, and logs, climatic factors, winter working requirements etc., the multi-component unit could be used with slurry-ponding, slurry-ditching or hydro-peat systems. Tough stringy wood and roots present a distinct problem, because their fibrous nature does not lend itself to easy maceration and may require a device more in the nature of a shredder.

284 FISONS-WESTERN WET-MINING OPERATION IN BRITISH COLUMBIA

Fisons-Western Peat Ltd. in British Columbia have a horticultural peat operation in production using a hover barge-mounted clamshell equipped with backhoe to excavate the peat and dump it into a hopper also mounted on the barge. The barge operates on a slurry-pond. Water monitors are used in the hopper to separate the peat from the high proportion of woody material found in these bogs. Once separated, the roots and stumps are combed out and removed. The peat-water slurry is then pumped to a mechanical press dewatering plant. The dry solids content of this slurry varies from about 0.75 to 1.5% dry solids by weight. A 4.5 km long, 400 mm diameter pipeline requires about 150 HP to pump 1500 to 1800 USGPM of this slurry to the dewatering plant. At the plant screens are used upstream of the Ingersoll-Rand Vari-Nip mechanical press. These screens pass fines of 35 mesh and under, largely colloidal peat, which is then pumped back to the bog with the water removed in the I-R dewatering press. The returned material is estimated as being 25% to 33% of the total harvested peat. This constitutes a large loss in material which has been pumped twice, 4.5 km each way (C.A. Carncross, 1980). A recent verbal communication from Trygve Sjothun of Fisons-Western indicates that a new system of screens installed in 1983 may reduce this loss to about half or less than formerly. The cost of peat harvested and delivered to the dewatering plant in this operation is reported by ORF as being $68.80/dry tonne in 1980 U.S. dollars (See Part 286 below).

It is understandable that Fisons use a great deal of water to separate the peat from the large proportion of wood which is found in their bogs. The jets of water from the monitors clean the peat off the roots and stumps, resulting in a thin peat slurry which is pumped to the dewatering plant. Given these conditions, it may not be profitable for Fisons to carry out extensive tests aimed at pumping a more concentrated slurry.

285 FEEDSTOCK REQUIREMENTS

Feedstock quantity requirements can be estimated on a dry solids basis, taking account of the losses sustained in each unit process and in-plant fuel requirements, where applicable. By this means, the quantity of slurried feedstock can be determined at the solids concentration of the slurry.

The quality of the feedstock, in terms of heating value and pumpability of the slurry at maximum solids concentration, would have to be determined by testing peat samples from the proposed resource which is to be exploited. Tests would be conducted to determine plant design parameters with respect to specific characteristics of the peat resource.

286 FEEDSTOCK COSTS

The cost of wet-mined slurried peat feedstock constitutes a major area of uncertainty in projecting the ex-plant cost of peat fuels.

Table 2.8-2 shows that an economic analysis of figures provided by JP-Energy results in a cost of slurried peat feedstock containing 9% solids at C$ 0.7154 per wet slurry tonne delivered to plant. This is equivalent to about C$ 8.00 per dry tonne and C$ 0.3723/GJ, at a production level of 270,000 dry tonnes per year.

Table 2.8-3 shows that an economic analysis of figures provided by VVI results in a cost of slurried peat feedstock at 7% solids at C$ 2.13 per wet slurry tonne delivered to plant. This is equivalent to C$ 30.43 per dry tonne at 17,500 dry tonnes per year product.

Fisons Western in B.C. are reported to produce wet-mined moss peat slurry at 1980 US$ 68.80* per dry tonne at 0.75-1.5% solids concentration.

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* INDICES: IMF: 2nd quarter 1980 U.S.$ 68.80 x 1.17 = C$ 80.50.
CPI: 1980 C$ 80.50 x 1.326 = 1983 C$ 106.74
Industry Selling: 1980 C$ 80.50 x 1.217 = 1983 C$ 97.97

ORF's report includes a good section on wet mining costs, which indicate a range of C$ 0.40 to C$ 4.80 per wet tonne for a variety of solids concentrations. The figure of C$ 4.80, which ORF have used as the basis of feedstock cost in their study refers to a 15% solids feedstock, and is equivalent to C$ 32.00 per dry tonne. It will be noted that this is close to the VVI cost of C$ 30.43 per dry tonne (above). ORF's production level of about 25,000 dry tonnes per year is also close enough to tht of VVI (17,500 dry tonnes per year) to make the comparison tenable. However, ORF's figures come from a peat excavating and trucking operation, while at the present time we do not have adequate technical support for VVI cost data. Hence, the similarity in their cost figures must be viewed with caution.

After studying all the figures and reports available, we are unable to find any consistent cost/production-level/solids-concentration relationship. We have, therefore, in our Analysis of Evaluation, compared only the costs of alternative dewatering and drying treatments for wet-mined, macerated, slurry-pumped, peat feedstock, and excluded the cost of the feedstock itself from our estimates.

TABLE 2.8-2
JP-ENERGY PROCESS 300,000 TONNES/YR. PLANT WET MINING AND STORAGE SYSTEM SLURRY PRODUCTION AND SUPPLY TO PLANT

	1983 CDN DOLLARS
CAPITAL INVESTMENT	13,500,000
ANNUAL CAPITAL CHARGES (20 yrs @ 15% CRF = 0.159761)	2,156,770
ANNUAL O&M COSTS	1,020,000
FIXED ANNUAL COST	3,176,770
ANNUAL VARIABLE COSTS	400,000
TOTAL ANNUAL COSTS	3,576,770
COST OF PRODUCT/WEIGHT (C$/TONNE) @ 5,000,000 TONNES/YR.	0.7154
COST OF PRODUCT/ENERGY (C$/GJ)	0.3723

@ 1.9215GJ/Slurry-Tonne
@ 9% Solids Concentration
5,000,000 T/Yr. x 1.9215 GJ/T = 9.6075×10^6 GJ/Yr.

NOTES: Support for this analysis is available in Table 321-9.

Assumed HHV: 21.35 GJ/Dry Tonne for raw peat.

TABLE 2.8-3
VVI WET MINING, PRETREATMENT, SLURRY TRANSPORT & STORAGE SYSTEM
COST OF PRODUCT
1983 CDN DOLLARS

			EX-PLANT COST OF PRODUCT AT PLANT CAPACITY OF			
No.		Units	17,500 Tonnes/yr	50,000 Tonnes/yr	100,000 Tonnes/yr	300,000 Tonnes/yr
1.	Capital Investment	$	1,032,000	0	0	0
2.	Annual Capital Charges (CRF = 0.159761)	$/yr	165,000			
3.	Annual O&M Costs	$/yr	278,000			
	Fixed Annual Cost	$/yr	443,000			
4.	Annual Variable Costs	$/yr	89,600			
	Total Annual Costs	$/yr	532,600			
5.	Cost of Product/Weight	$/tonne	30.43	(X)		
6.	Cost of Product/Energy (350,000 GJ/yr)	$/GJ	1.52	(Y)		

Notes: (X) This is equivalent to C$2.13 per wet slurry tonne @ 7 wt % solids concentration. See Note (X) on Table 331-4.

(Y) Assuming that the raw peat has HHV of 20 GJ/tonne on a dry basis, and assuming no peat solids are lost in dewatering.

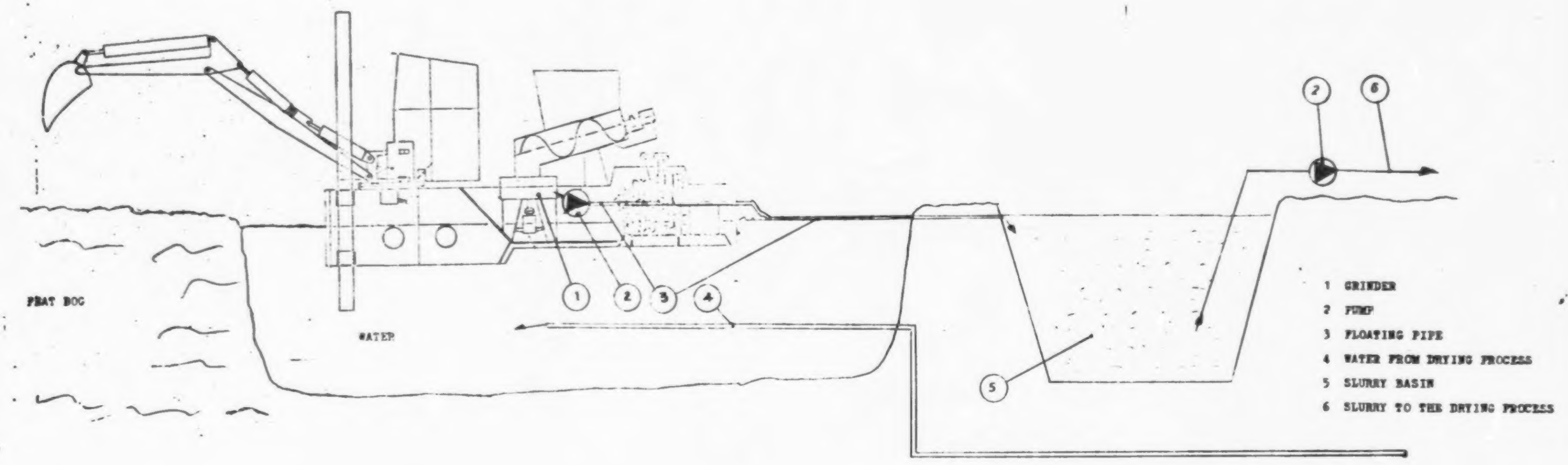
PEAT BOG
WATER
1
2
3
4
5
2
6
1 GRINDER
2 PUMP
3 FLOATING PIPE
4 WATER FROM DRYING PROCESS
5 SLURRY BASIN
6 SLURRY TO THE DRYING PROCESS

FIGURE 2.8-1

VVI WET-MINING AND PRETREATMENT
OF PEAT FOR SLURRY PUMPING
TO VVI-PEAT DEWATERING PLANT

PART 3

REVIEW AND EVALUATION OF TECHNOLOGIES

PART 4

REFERENCES AND ACKNOWLEDGEMENTS

4.1 REFERENCES

The documents listed below are not related by number to sections in the report, because the data for this report was obtained mainly by visits to, or by direct personal communication with, process and equipment sources. The data in this report thus constitutes update of information and, in some cases, further development of information contained in the source material listed below. There are, however, two significant exceptions:

- A report by Ontario Research Foundation dated December 1982, sponsored by CANMET, EM&R Ottawa, entitled "Investigation of the Application of Wet Oxidation Technology to the Dewatering and Combustion of Peat".
- A report by Zimpro Incorporated dated January 1983, sponsored by the U.S. Department of Energy, Grand Forks Energy Technology Centre, entitled "Investigation of Peat Wet Oxidation Process".

These two reports were provided to Monenco to be used as reference material for the study. Data from them, combined with data obtained during team visits, and by personal communication, has been used in the preparation of Parts 323 and 324 which are the respective parts of this report evaluating the ORF-Wetox and Zimpro processes.

Some of the reference material listed below has been quoted occasionally in the report. On such occasions the source or the author have been named in the text so that the use of reference numbers could be avoided.

NO.	REFERENCE
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2.	Bettinger, J.A., Lamparter, R.A., and McDowell, D.C. "Coal Combustion by Wet Oxidation", Mich. Tech. Univ., November 1980, DOE/FG22-78 ET 12328.
3.	Bostwick, L.E., Fruchtbaum, J. and Hubbard, D.A. "Evaluation of One Method of Peat Harvesting and Dewatering", March 1981, Engineering Support Services for the DOE/GRI Coal Gasification Research Program, The M.W. Kellogg Company, Houston, Texas, U.S. Department of Energy and The Gas Research Institute, Under Contract ET-78-C-01-2778.

NO. REFERENCE

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"Carver-Greenfield Process for Drying of Peat", Foster Wheeler Spec, Inc., IGT Symposium Peat as an Energy Alternative II, December 1981.

5. Chornet, E.
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